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AEFA Project No. 84-33

COMBINED PRELIMINARY AIRWORTHINESS EVALUATION AND AIRWORTHINESS & FLIGHT CHARACTERISTICS EVALUATION OF THE UH-1H WITH PREPRODUCTION HUB SPRING AND COMPOSITE MAIN ROTOR BLADES INSTALLED

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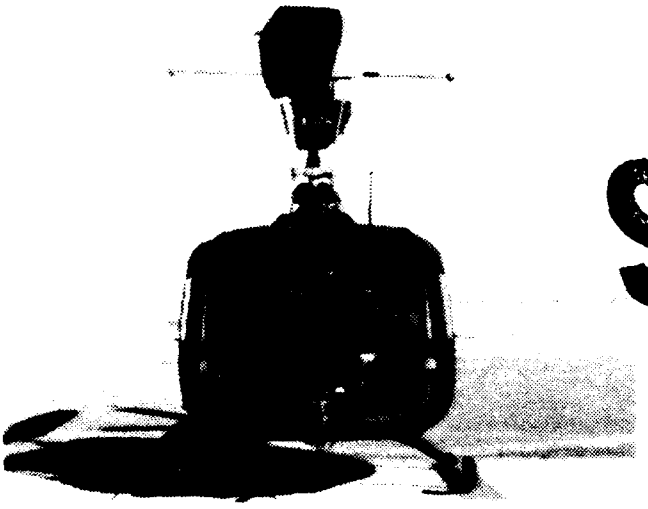
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July 1988
Final Report



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The U.S. Army has incorporated a main rotor hub spring on the UH-1H helicopter designed to reduce large main rotor flapping angles which occur during some flight maneuvers. Composite main rotor blades (CMRB), were also incorporated which are intended to increase performance and to improve reliability and survivability of the UH-1H helicopter. A Preliminary Airworthiness Evaluation was conducted to substantiate increased performance and determine suitability of the combined preproduction CMRB and hub spring configuration for compliance with the CMRB Critical Item Development Specification (CIDS), and subsequent release to operational users. An Airworthiness and Flight Characteristics evaluation was required to obtain detailed performance, vibration and stability and control information to document the UH-1H hub spring and CMRB installation. Due to high vibration characteristics and the occurrence of cyclic control feedback contributing to loss of aircraft control associated with CMRB, additional testing was conducted for comparison with standard metal main rotor blades (STD) and composite main rotor blades constructed with production tooling (PROD CMRB). Testing was evaluated under a variety of operating conditions at test sites from field elevations of 2302 ft to 9980 ft. Total project flight time was 272 hours of which 121 hours were productive. Some improvement was noted in out-of-ground effect hover performance with PROD CMRB compared to CMRB, while level flight performance of the CMRB and PROD CMRB was not significantly

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different. Performance improved for the PROD CMRB compared to STD, but did not meet the requirements of the CIDS. Handling qualities are similar for CMRB and PROD CMRB, and deteriorated when compared to STD with regard to maneuvering characteristics and main rotor speed control during autorotation. Vibration levels are similar for CMRB and PROD CMRB and in general higher than STD which produced a more comfortable ride. An operational main rotor speed of 324 rpm instead of the previously proposed 314 rpm is recommended for PROD CMRB because of the reduced chance of feedback at increased load factors, lower pitch link loads during roll reversals, better directional control in low speed flight without penalty in hover performance, greater available reaction time in the event of an engine failure and reduced vibrations. There were two deficiencies, seven shortcomings, five CIDS noncompliances, three military specification MIL-H-8501A noncompliances, and one possible MIL-H-8501A noncompliance identified. The two deficiencies, possibility of temporary loss of aircraft control limiting maneuvering flight and increased pilot workload to control rotor speed during an autorotational landing, can be compensated for through training.

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INTRODUCTION

BACKGROUND

1. A main rotor hub spring for the UH-1H helicopter has been developed by Bell Helicopter Textron, Inc., (BHTI) under contract to the U.S. Army. The intent of the hub spring is to reduce large main rotor flapping angles which occur during some flight maneuvers. A prototype hub spring kit was previously evaluated by the U.S. Army Aviation Engineering Flight Activity (AEFA) and results reported in AEFA Project No. 84-31 (ref 1, app A). Subsequently, a production decision was made to incorporate the hub spring on the UH-1H helicopter. The U.S. Army is also incorporating composite main rotor blades (CMRB) designed to increase performance and to improve reliability and survivability of the UH-1H helicopter. A Preliminary Airworthiness Evaluation (PAE) was required to substantiate increased performance and determine suitability of the combined preproduction CMRB and hub spring configuration for release to operational users. An Airworthiness and Flight Characteristics (A&FC) evaluation was required to obtain detailed performance, vibration and stability and control information to document the UH-1H hub spring and CMRB installation. In June 1986, the U.S. Army Aviation Systems Command (AVSCOM) initially tasked AEFA (ref 2) to conduct a combined PAE and A&FC of the UH-1H helicopter equipped with preproduction main rotor hub spring and CMRB. Based upon inconclusive results of initial testing, AVSCOM requested that additional vibration testing be conducted with the CMRB and standard metal main rotor blades (STD) at similar conditions to insure accurate comparison of their respective vibration characteristics (ref 3). AVSCOM further requested additional testing be conducted to define the limiting maneuvering envelopes of the UH-1H helicopter configured with composite main rotor blades constructed with production tooling (PROD CMRB) and STD (ref 4).

TEST OBJECTIVES

2. The objectives of the combined and additional testing were as follows.

a. To determine compliance with performance requirements of the CMRB Critical Item Development Specification (CIDS) (ref 5), confirm main rotor flapping margins and obtain limited handling qualities data to substantiate preparation of an airworthiness release for operational use.

b. To obtain sufficient performance and handling qualities data to support changes to the operator's manual (ref 6).

c. To determine and compare the vibration characteristics of a UH-1H helicopter with the preproduction hub spring and CMRB, PROD CMRB and STD installed.

d. To determine and compare the maneuvering envelopes of a UH-1H helicopter with preproduction hub spring and CMRB, PROD CMRB and STD installed.

DESCRIPTION

3. The UH-1H is a thirteen-place, single-engine helicopter with a maximum gross weight of 9500 pounds (lb). Lift is provided by a single two-bladed, 48-foot diameter teetering main rotor. Antitorque and directional control is provided by a two-bladed pusher-type tail rotor. Power is provided by a Lycoming T53-L-13B free turbine engine with an uninstalled power rating of 1400 shaft horsepower (shp) at sea level standard day conditions. Drive train limits derate engine performance to 1157 shp at a main rotor speed of 324 revolutions per minute (rpm). A preproduction elastomeric main rotor hub spring was installed in conjunction with CMRB and PROD CMRB for this evaluation. The hub spring attaches to the mast providing a cushion for the hub at approximately 45 percent (%) flapping angle. The composite main rotor blade incorporates three different airfoil sections constructed basically from fiberglass in an epoxy resin material with the leading edge protected by a non-metallic abrasion strip. These items are described in more detail in appendix B, and references 5 and 7, appendix A. The test aircraft, USA S/N 68-16358 (fig. 1), is representative of a production UH-1H helicopter with the exception of the installation of the main rotor hub spring and CMRB. A more detailed description of the UH-1H is contained in appendix B and reference 6, appendix A.

TEST SCOPE

4. Testing was conducted to evaluate performance and handling qualities and to determine main rotor flapping margins, vibration characteristics and maneuvering envelope limits. A majority of the flight test program was conducted at Edwards Air Force Base, (field elevation 2302 feet (ft)), with additional testing conducted at Bishop (4120 ft elevation) and Coyote Flat (9980 ft elevation), California between 30 July 1986 and 16 November 1987. Difficulties encountered with the CMRB and additional testing requested by AVSCOM increased project costs and delayed completion time. Therefore, deletion of some less critical handling qualities test conditions was requested by AEFA and approved by AVSCOM. Modified PAE and A&FC testing totaled 163 flight hours of which 100 hours were productive. Additional testing required 38 flight hours of which 21 hours were productive. Total flight time for the project was 272 hours which included maintenance and ferry time. AEFA was responsible for maintaining the test aircraft and providing chase support. BHTI installed and maintained the test aircraft instrumentation with supplementary support from AEFA. Flight restrictions and operating limitations contained in the operator's manual and the airworthiness release (refs 6 and 8, app A) were observed as guidelines. Testing was conducted in accordance with the test plan (ref 9). Initial tests were conducted with one BHTI and one Boeing preproduction CMRB installed. The remainder of testing was completed with composite main rotor blades made from BHTI production tooling. Testing with STD was initially accomplished to establish baseline data for determining change in performance between STD and CMRB as required by the CIDS, and subsequently for comparison with CMRB and/or PROD CMRB vibration characteristics, maneuvering envelopes and main rotor speed control. Compliance with specified performance requirements was determined utilizing

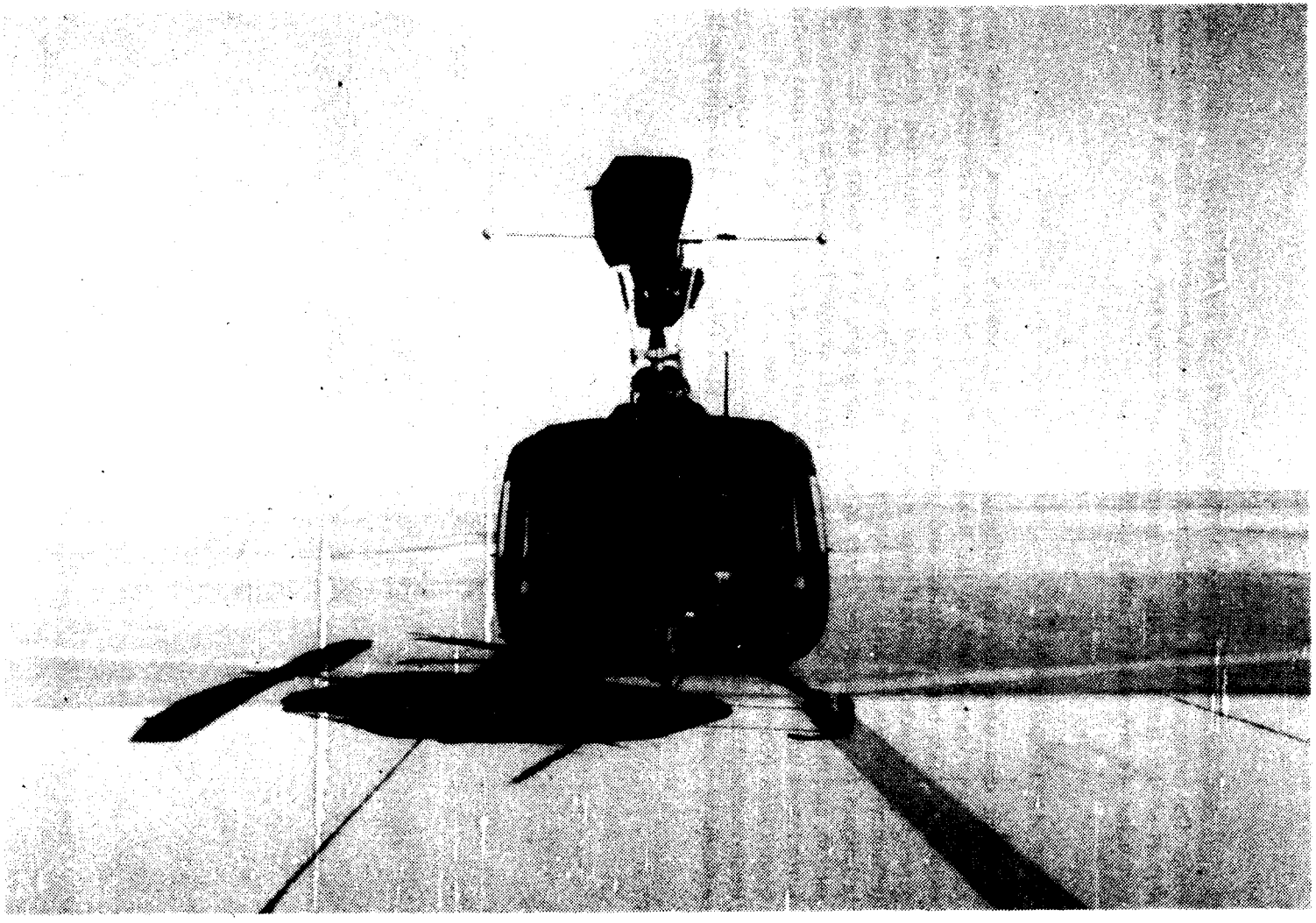


Figure 1. Test Aircraft

power available and fuel flow from AEFA Project No. 66-04 (ref 10), as directed by the CIDS. The helicopter was also evaluated against the requirements of military specification MIL-H-8501A (ref 11). Test configurations and conditions at which all testing was conducted are presented in tables 1 and 2.

TEST METHODOLOGY

5. Flight data were recorded utilizing cockpit instruments, airborne magnetic tape recorder, and via telemetry to the Real Time Data Acquisition and Processing System (RDAPS). Test instrumentation and parameters are listed in appendix C. All flight parameters considered critical were monitored in real time. Established flight test techniques and data analysis procedures (ref 12 and 13, app A) were used. Flight test techniques are discussed for clarity in some paragraphs of the results and discussion section, and thoroughly described along with the data analysis procedures in appendix D. Performance information for the operator's manual utilized the T53-L-13B engine model specification (Computer Deck No. 19.28.25.03), reference 14, appendix A, as a basis. Performance data were corrected for instrumentation electrical load. Vibrations were assessed in accordance with the Vibration Rating Scale (VRS) presented in appendix D.

Table 1. Performance General Test Conditions[1]

Type of Test	Gross Weight (lb)	Longitudinal Center of Gravity (FS)	Density Altitude (ft)	Trim Calibrated Airspeed (KT)	Referred Rotor Speed (rpm)	Blade Configuration
Hover	6600 to 9700[2]	135 (MID)	3200[3] and 11,000[4]	0	299 to 333	CMRB[5]
	6900 to 10,000[2]		3700[4]		287 to 321	PROD CMRB[6]
	6700 to 9600[2]		2400[3]		294 to 324	STD[7]
Forward Flight Climb	7700	133 (FWD)	5000	58[8]	314[9] and 324[9]	PROD CMRB
			10,000	53[8]		
Level Flight	7900 to 9000	133 (FWD)	5800 to 12,100	40 to V_{NE}[10]	304 and 313	CMRB
	7500 to 9500		4500 to 11,000		304, 314, 324	PROD CMRB
	8300		4300 to 10,300		314 and 324	STD
Autorotational Descent	7200 to 8400	132 (FWD)	5000 and 10,000	35 to 110	285[9] to 325[9]	PROD CMRB

NOTES:

[1]Tests conducted in the doors closed configuration, bleed air off, mid lateral center of gravity, with the preproduction main rotor hub spring installed.
[2]Aircraft weight plus cable tension.
[3]Out-of-ground effect only.
[4]Skid height of 2 ft, 5 ft and out-of-ground effect.
[5]Preproduction composite main rotor blades.
[6]Production composite main rotor blades.
[7]Standard metal main rotor blades.
[8]Best rate of climb airspeed.
[9]Actual rotor speed.
[10]V_{NE} : Never exceed airspeed.

Table 2. Handling Qualities General Test Conditions[1]

Type of Test	Gross Weight (lb)	Longitudinal Center of Gravity (FS)	Rotor Speed (rpm)	Density Altitude (ft)	Trim Calibrated Airspeed (kt)	Flight Condition	Rotor Configuration
Control Positions in Trimmed Forward Flight	-----	-----	-----	-----	-----	Flown in conjunction with level flight performance testing	CMRB[2] PROD CMRB[3] STD[4]
Static Longitudinal Stability	7500	140 (AFT)	314 and 324	8000	100	Level	PROD CMRB
	8500	133 (FWD)	324	6000	65 and 95	Level	CMRB
					55	1000 fpm climb	
					60	Autorotation	
	8400	142 (AFT)	314		65 and 95	Level	
					55	Max power climb	
					60	Autorotation	
	9500	140 (AFT)	314 and 324	8000	90	Level	PROD CMRB
Static Lateral-Directional Stability	8500	142 (AFT)	314 and 324	6000	55 and 105	Level	CMRB
Maneuvering Stability	8300	133 (FWD) 142 (AFT)	314 and 324 314	6000	76 and 97 97	Wind-up turn and push-over	CMRB
Maneuvering Envelope	7500	140 (AFT)	314 and 324	8000	65, 80, 90, 100	Wind-up turn	CMRB PROD CMRB STD
					65, 80, 95	Autorotation	
	8500				65, 80, 90, 95	Wind-up turn	
					65, 80, 95	Autrotation	
	9500				65, 80, 85, 90	Wind-up turn	
Roll Reversals	8300	132 (FWD)	314 and 324	7000	75 and 95	Level	CMRB
Dynamic Stability	8200	132 (FWD)	324	6000	65 and 95	Level	CMRB
		142 (AFT)	314		55	Max power climb	
					60	Autorotation	
Controllability	8500	132 (FWD)	324	6000	72 and 95	Level	CMRB
		142 (AFT)	314 and 324	2000	0	Hover	
			314		75 and 96	Level	
			324	6000	54	Max power climb	
					60	Autorotation	
	8700	132 (FWD)	314	10,500	15 KTAS[5]	Critical azimuth	
	8000			800	25 and 30 KTAS		
Low Speed Flight Characteristics[6]	8500	133 (FWD)	314 and 324[7]	400 to 10,500	0 to 30 KTAS	Mid BL	CMRB
				400		BL = 4 lt	
				10,500	5 KTAS	BL = 3 lt	
Forward Acceleration/ Deceleration	8400	133 (FWD)	324	2500	0 to 118 to 0	Level	CMRB
Lateral Acceleration/ Deceleration	8200	132 (FWD)	324	400 to 4500	0 to 30 KTAS to 0	Mid BL	CMRB
			314	600		BL = 4 lt	
Simulated Engine Failure	8500	134 (FWD)	324	6500	70 to 105	Level, mid BL; BL = 4 lt	CMRB
		142 (AFT)			60	Max power climb	
	7000	133 (FWD)			70 to 105	Level, mid BL	PROD CMRB
					90 to 116	Level, mid BL	
Hydraulic System Failure	8500	133 (FWD) and 142 (AFT)	314 and 324	6000	40 to 115	Level, climb[8], descent[8], approach to running landing	CMRB
				10,000	40 to 90		
	7900	133 (FWD)				Approach to running landing	
Autorotational Landing	7500	139 (AFT)	314	4000	65, 90, 95	Straight approach	CMRB
					90	180 deg turn approach	PROD CMRB
Vibrations	7500	136	314 and 324	1000 to 8500[9]	0	Hover	CMRB
	8700	138			45 to 120	Level	PROD CMRB
	9600	135					STD
	8700	138		6000	96	Wind-up turn	
Control Loads	-----	-----	-----	-----	-----	Flown in conjunction with maneuvering envelope testing	CMRB PROD CMRB STD

NOTES:
[1]Tests conducted in the doors closed configuation, mid lateral center of gravity (BL), with the preproduction main rotor hub spring installed, unless otherwise
[2]Preproduction composite main rotor blades.
[3]Production composite main rotor blades.
[4]Standard metal main rotor blades.
[5]KTAS: Knots true airspeed.
[6]Skid height of 10 to 15 ft.
[7]Conducted when control limit reached at rotor speed of 314 rpm.
[8]Conducted at rotor speed of 324 only.
[9]Hover conducted at 1000 to 2000 feet density altitude. Level flight conducted at 3500 to 8500 feet density altitude.

RESULTS AND DISCUSSION

GENERAL

6. The performance and handling qualities of the UH-1H with the preproduction hub spring and composite main rotor blades installed were evaluated under a variety of operating conditions at test sites from field elevation of 2302 ft to 9980 ft. Initial tests were conducted with CMRB installed, one blade manufactured by BHTI and the other by The Boeing Company. The acronym CMRB used in this report refers to the preproduction constructed composite main rotor blades. Subsequent testing was accomplished with two PROD CMRB constructed by BHTI. Some improvement was noted in out-of-ground effect (OGE) hover performance with the PROD CMRB installed, and though minor differences were noted in level flight performance between CMRB and PROD CMRB, overall level flight results are the same. Testing with STD was accomplished to establish baseline data for determining the change in performance between STD and CMRB as required by the CIDS. Performance improved for the UH-1H helicopter incorporating PROD CMRB when compared to STD, but failed the requirements of the CIDS. There was no significant difference noted in handling qualities with CMRB or PROD CMRB installed. The maneuvering envelope was determined to be similar for CMRB, PROD CMRB and STD, and generally was less than the envelope prescribed in the operator's manual. Most maneuvering can be performed in a moderately aggressive manner with adequate flapping margins remaining. Adequate cues exist, to alert a pilot experienced in operation of a UH-1H with CMRB installed, of hub spring contact. Loss of aircraft control was more likely to occur with PROD CMRB than with STD because of the rapid and unpredictable onset of cyclic control feedback. The difficulty in main rotor speed control associated with CMRB or PROD CMRB, especially during autorotation, can be compensated for through training. Vibration levels are similar for CMRB and PROD CMRB, and in general are higher compared to STD which produced a more comfortable ride. An operational main rotor speed of 324 rpm instead of the previously proposed 314 rpm is recommended for PROD CMRB because of the reduced chance of feedback at increased load factors, lower main rotor pitch link loads during roll reversals, better directional control in low speed flight without penalty in hover performance, greater available reaction time in the event of an engine failure and reduced vibrations. There were two deficiencies and seven shortcomings associated with installation of the hub spring and CMRB or PROD CMRB on the UH-1H helicopter.

PERFORMANCE

Hover Performance

7. Hover performance tests were conducted at the conditions listed in table 1 to determine in-ground effect (IGE) and OGE hover capability of the helicopter. Tether and free flight hover techniques were utilized. Results are presented in figures E-1 through E-6, appendix E.

8. Nondimensional CMRB and PROD CMRB test results were the same for a 2 foot skid height, but dissimilar OGE. Slightly more power was required OGE for CMRB as compared to PROD CMRB. This difference in power required between CMRB and

PROD CMRB tended to enlarge with increasing thrust coefficient (C_T). The OGE fairing of figure E-5 represents a PROD CMRB installation and was obtained by using the shape of the curve generated by CMRB data. The OGE hover ceiling at a maximum gross weight of 9500 lb with PROD CMRB installed for standard day conditions was 9420 ft, and decreased to 1600 ft pressure altitude at 35 degree (°) Centigrade (C). The 2-foot hover capability at a gross weight of 9500 lb at 35° C was 5930 ft pressure altitude.

9. Compliance of test results with specified hover performance requirements is depicted in figure 2 and tabularized in table 3. The improvement in gross weight capability for OGE hover at a rotor speed of 324 rpm at 4000 ft pressure altitude and 35°C was 2.4% for the CMRB and 4.6% for the PROD CMRB and failed to meet the requirement of 6.0% specified by the CIDS.

10. No compressibility trend was observed in hover performance within the rotor speed/temperature range tested with the CMRB or PROD CMRB installed; however, a decrease in performance was noted above rotor speeds of 314 rpm with STD installed (fig. E-6). This apparent compressibility effect on hover performance with STD is noticeable in the data presented in reference 10. Fairings of the same form used in this analysis of STD data were used in a reanalysis of the data of reference 10 to substantiate compressibility effects associated with STD. Results of this reanalysis showing the effect of rotor speed is presented in figure 3. The PROD CMRB hover performance results contained in this report should be used in revising the UH-1H operator's manual for inclusion of PROD CMRB, and the reanalyzed fairings for STD should be used to define hover performance with STD installed.

Forward Flight Climb Performance

11. Forward flight climb performance tests were conducted at the conditions listed in table 1 to determine the effect of power variation on rate of climb, and consequently the climb correction factor for power (Kp). Test results are shown in figure E-7 for the PROD CMRB. Climb performance was slightly improved for a main rotor speed of 314 rpm at 5000 ft density altitude, particularly at lower power settings; however, at 10,000 ft density altitude climb performance was degraded for a rotor speed of 314 rpm compared to 324 rpm, possibly due to blade stall. The line fairing of figure E-7 represents a nominal Kp of 0.83, a slight increase over 0.80 determined from reference 10, appendix A for STD.

Level Flight Performance

12. Level flight performance tests were conducted in zero sideslip flight at the conditions listed in table 1 to determine power required and associated fuel flow as a function of airspeed. Testing was initially accomplished with CMRB at average referred rotor speed(s) ($N_R/\sqrt{\theta}$) of 303.7 and 313.4 rpm. Follow-on testing was conducted with PROD CMRB at $N_R/\sqrt{\theta}$ averaging 303.7, 314.0 and 323.8 rpm. Testing with STD was conducted at $N_R/\sqrt{\theta}$ averaging 313.8 and 323.9 rpm for comparative purposes.

FIGURE 2

HOVER PERFORMANCE COMPARISON

UH-1H USA S/N 68-16358

SKID HEIGHT = 60 FT(OGE)

SOLID LINE	PROD CMRB (NO ROTOR SPEED EFFECT)
LONG DASHES	CMRB (NO ROTOR SPEED EFFECT)
SHORT DASHES	STD BLADES REFERRED ROTOR SPEED = 313.3 (Nr = 324, 35 DEG C)
LONG AND SHORT DASHES	STD BLADES REFERRED ROTOR SPEED = 324.0 (Nr = 324, 15 DEG C)

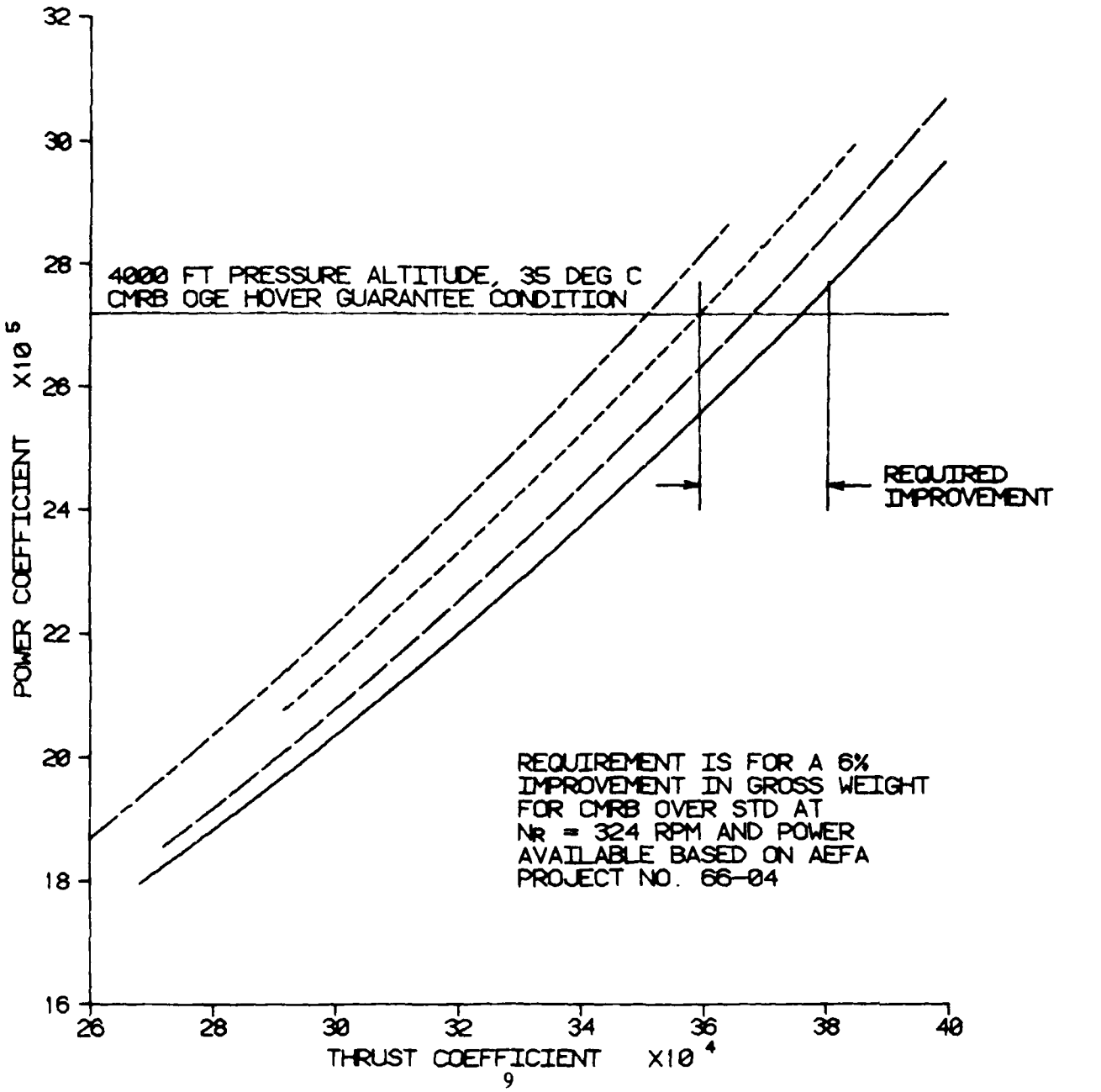


Table 3. OGE Hover Performance Requirement[1]

Rotor Blade Type	Rotor Speed (rpm)	Referred Rotor Speed (rpm)	Temperature (deg C)	Pressure Altitude (ft)	Maximum Gross Weight Capability (lb)	Percent Difference From STD (%)	Guarantee (%)
STD[2]	324	313.3	35	4000	8284	--	--
CMRB[3]	324	313.3	35	4000	8482	2.4	6.0
PROD CMRB[4]	324	313.3	35	4000	8664	4.6	6.0

NOTES:

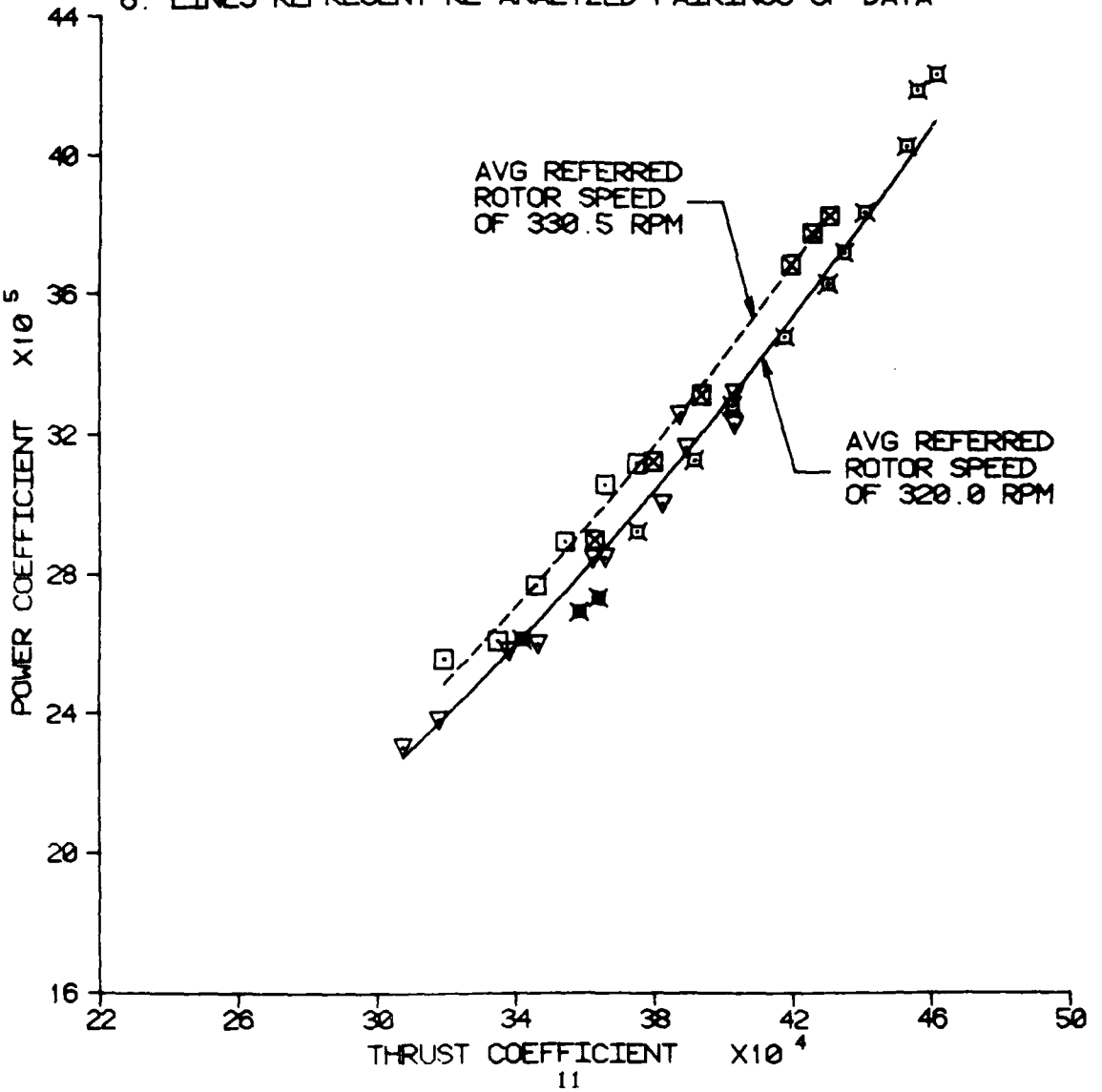
[1]Requirement is for 6% improvement in gross weight for CMRB over STD at a rotor speed of 324 rpm. Power available is based on AEFA Project No. 66-04 as required by the CMRB Critical Item Development Specification.
[2]Standard metal main rotor blades.
[3]Preproduction composite main rotor blades.
[4]Production composite main rotor blades.

FIGURE 3
NONDIMENSIONAL HOVER PERFORMANCE
UH-1H USA S/N 60-6029

SKID HEIGHT = 60 FT (OGE)

SYMBOL	DENSITY ALTITUDE (FT)	OAT (DEG C)	ROTOR SPEED (RPM)	REFERRED ROTOR SPEED (RPM)
⊠	12420	2.0	324	332
⧈	12420	2.0	314	321
⊡	4550	6.0	324	329
▽	4550	6.0	314	319

NOTES:
1. STANDARD BLADES CONFIGURATION
2. TESTS CONDUCTED WITH AIRCRAFT TETHERED TO THE GROUND
3. SHADED SYMBOLS DENOTE FREE FLIGHT TECHNIQUE
4. WINDS LESS THAN 3 KNOTS
5. DATA OBTAINED FROM USAAEFA REPORT NO. 66-04
6. LINES REPRESENT RE-ANALYZED FAIRINGS OF DATA



13. Nondimensional test results are presented in figures E-8 through E-13, appendix E. Some differences were noted in level flight performance between CMRB and PROD CMRB, but were not significant. Power required generally increased with increasing $N_R/\sqrt{\theta}$, primarily at higher advance ratios (μ). The benefits of decreasing main rotor speed to achieve an increase in efficiency (deceasing power required and corresponding fuel flow), appeared to diminish with increasing C_T for CMRB or PROD CMRB at $N_R/\sqrt{\theta}$ below 314 rpm, attributable possibly to blade stall.

14. Dimensional level flight test results are presented in figures E-14 through E-31. The never exceed airspeed (V_{NE}) limit was reached before encountering the aircraft torque limit for all conditions tested. The difference in specific range noted on each dimensional level flight figure was because test engine fuel flow was consistently higher than specification fuel flow. This indicates that the engine used during this test did not meet the minimum specification requirements for a new engine; however, as shown in figure E-32, engine condition did not deteriorate and the relationship of referred shp to referred fuel flow was consistent throughout the test program.

15. Compliance with specified guarantees was determined using fuel flow from reference 10, appendix A as required by the CIDS. Results are depicted in figures 4 and 5, and tabularized in table 4. The CIDS specifies that main rotor speed be 314 rpm for the CMRB or PROD CMRB and 324 rpm for the STD. At sea level standard day conditions and an aircraft weight of 9500 lb, the CIDS requires fuel flow at 100 knots true airspeed (KTAS) for the PROD CMRB to be 8.5% less than for the STD at their respective rotor speeds. At these conditions, the difference was 7.0% which failed the requirement of the CIDS. Comparing the PROD CMRB and STD at the same rotor speed yielded a difference in fuel flow of 6.3% at 324 rpm and 3.3% at 314 rpm. At 4000 ft pressure altitude, 35°C and 8000 lb gross weight, the CIDS requires fuel flow at a 100 KTAS for the PROD CMRB to be 5.1% less than for the STD at their respective referred rotor speeds. At these conditions, the difference in fuel flow was 4.0% which failed the requirement of the CIDS. The level flight performance results contained in this report should be used in revising the UH-1H operator's manual for inclusion of PROD CMRB.

Autorotational Descent Performance

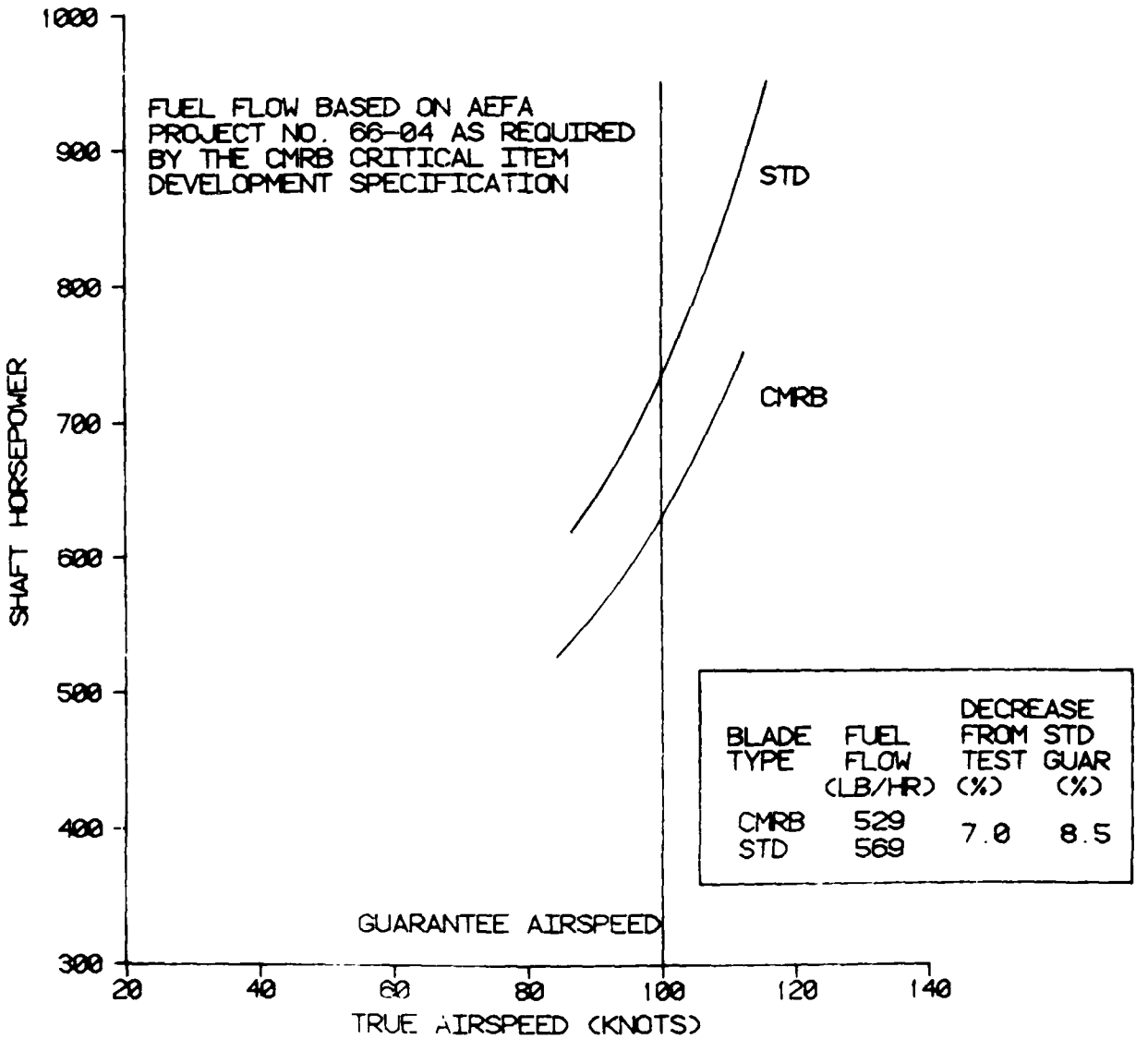
16. Autorotational descent performance tests were accomplished at the conditions noted in table 1. Aircraft rigging prevented achieving an autorotative main rotor speed of 314 rpm at both 5000 and 10,000 ft test density altitudes at an average gross weight of 7700 lb. The maximum achievable rotor speed at 5000 ft density altitude throughout the airspeed range was approximately 300 rpm. Airspeed was varied at 5000 and 10,000 ft at rotor speeds of 300 and 313 rpm, respectively, to determine autorotational descent performance with PROD CMRB installed. At the airspeeds for maximum rate of climb at 5000 and 10,000 ft density altitudes, rotor speed was varied to determine the effect on autorotational descent performance. Test results are presented in figures E-33 and E-34, appendix E.

FIGURE 4

LEVEL FLIGHT PERFORMANCE
UH-1H USA S/N 68-16358

SEA LEVEL, 15 DEG C
GROSS WEIGHT = 9500 LB

CMRB/HUB SPRNG N_R = 314 RPM
STD/HUB SPRNG N_R = 324 RPM



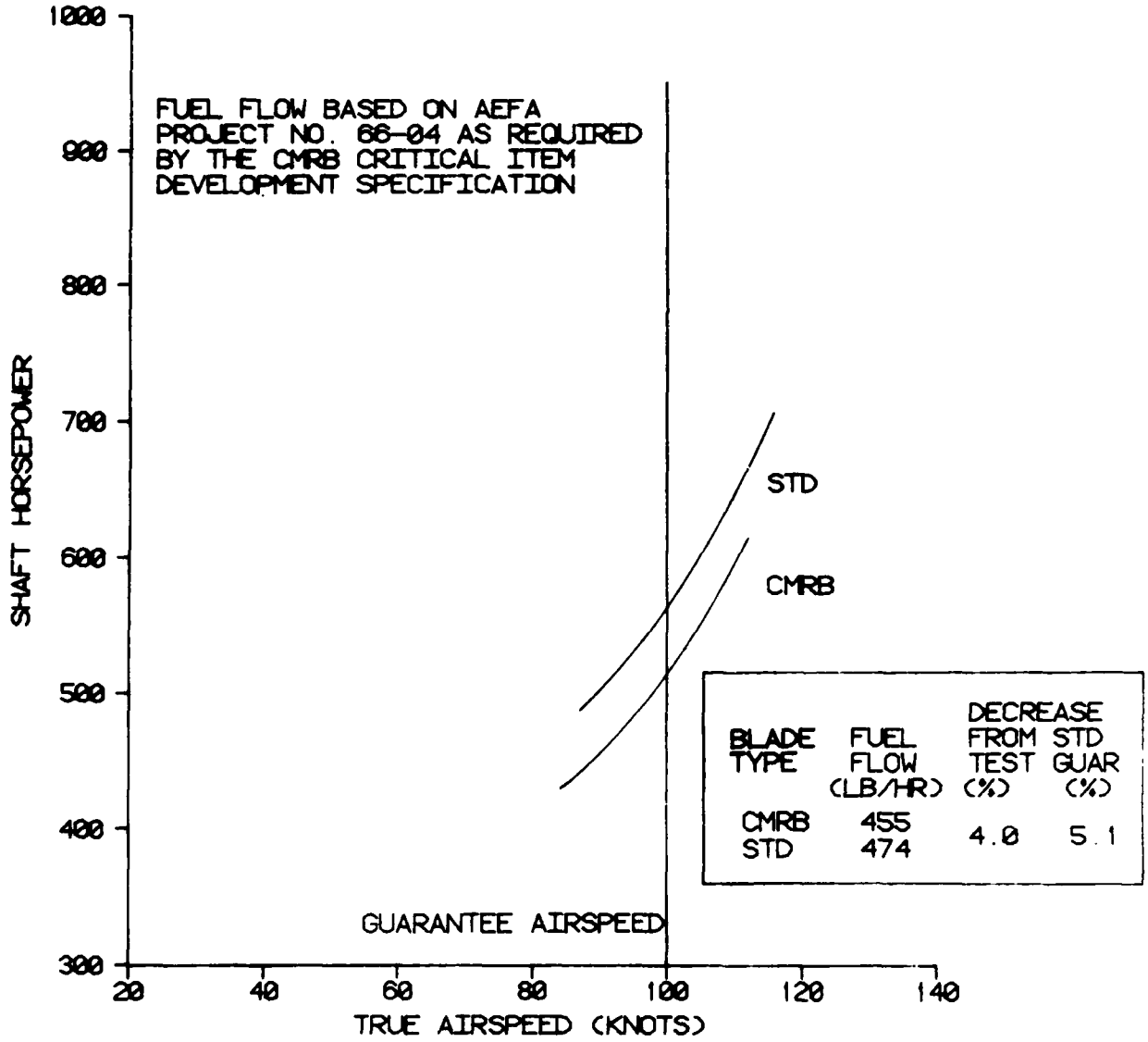
BLADE TYPE	FUEL FLOW (LB/HR)	DECREASE FROM STD TEST (%)	DECREASE FROM STD GUAR (%)
CMRB	529	7.0	8.5
STD	569		

FIGURE 5

LEVEL FLIGHT PERFORMANCE
UH-1H USA S/N 68-16358

4000 FT, 35 DEG C
GROSS WEIGHT = 8000 LB

CMRB/HUB SPRNG N_R = 314 RPM
STD/HUB SPRNG N_R = 324 RPM



BLADE TYPE	FUEL FLOW (LB/HR)	DECREASE FROM STD TEST (%)	DECREASE FROM STD GUAR (%)
CMRB	455	4.0	5.1
STD	474		

Table 4. Summary of Level Flight Performance at 100 KTAS

Rotor Blade Type	Rotor Speed (rpm)	Referred Rotor Speed (rpm)	Temperature (deg C)	Pressure Altitude (ft)	Gross Weight (lb)	Shaft Horsepower (shp)	Fuel Flow (lb/hr)	Decrease From STD	
								Test (%)	Guarantee (%)
STD[1]	324	324	15	Sea Level	9500	733	569	7.0	8.5
PROD CMRB[2]	314	314				628	529		
STD	324	313.3	35	4000	8000	563	474	4.0	5.1
PROD CMRB	314	303.6				513	455		
STD	324	324	15	Sea Level	9500	733	569	6.3	--
PROD CMRB	324	324				639	533		
STD	314	314				674	547	3.3	--
PROD CMRB	314	314				628	529		

NOTES:

[1]Standard metal main rotor blades.
[2]Production composite main rotor blades.

17. The airspeed for minimum rate of descent was 60 knots calibrated airspeed (KCAS) regardless of altitude or main rotor speed within a rotor speed range from 300 to 314 rpm. Rate of descent varied only approximately 15 ft/min within this rotor speed range. Main rotor speed in an autorotational descent should be maintained within 300 to 314 rpm to maintain a minimum rate of descent. Airspeed can vary ± 5 knots about 60 KCAS without increasing the rate of descent 15 ft/min or 1%. Minimum rate of descent at a gross weight of 7700 lb was 1700 ft/min at 10,000 ft density altitude, and 1575 ft/min at 5000 ft density altitude at 60 KCAS. Test results to determine the effect on autorotative rate of descent of varying gross weight were inconclusive due to the limited amount of data collected. The airspeed for maximum glide distance was 81 KCAS regardless of altitude within the recommended rotor speed range. Though rotor speed control was poor during autorotation resulting in variations of approximately 15 rpm (para 40), this variance coincides with the extent of the recommended rotor speed range and should be achievable without adversely affecting descent performance during an actual autorotation.

HANDLING QUALITIES

Control Positions in Trimmed Forward Flight

18. Control positions in trimmed forward flight were obtained concurrently with level flight performance testing at zero sideslip for the conditions listed in table 1. Data are presented in figures E-35 through E-39. Control positions in climbing and autorotational flight were qualitatively evaluated in ball-centered flight. The variation of longitudinal control position with airspeed during level flight was essentially linear requiring increasing forward cyclic control with increasing airspeed. Movement in longitudinal center of gravity (cg) 9 inches (in.) aft reduced the longitudinal control position gradient by nearly two-thirds (fig. E-35). Lateral and directional control positions exhibited no discontinuities throughout the airspeed range. There were no disconcerting shifts in control positions while transitioning from powered to autorotational flight. A shift in longitudinal cg forward or an increase in altitude decreased main rotor flapping margins (increased flapping) (figs. E-35 and E-38). Pitch attitude trends were similar at all conditions tested, with only an approximately 5° change in pitch attitude associated with a shift in longitudinal cg of 9 in. (fig. E-35). At airspeeds above 100 KCAS, the increased vibration level associated with CMRB (para 44) adversely affected ability to trim the aircraft at a precise airspeed. The pitch instability in maximum power climb (para 29) and difficulty of rotor speed control in autorotation (para 40), increased pilot workload so that the ability to achieve a trim condition is deteriorated. Adequate control margins existed throughout all flight conditions tested, and control position linearity and gradient were essentially the same as a UH-1H helicopter with STD installed (fig. E-39). Control positions in forward flight and trimmability of the UH-1H helicopter with hub spring and CMRB are satisfactory.

Static Longitudinal Stability

19. The static longitudinal stability characteristics were evaluated in level, climbing, and autorotative flight at the conditions listed in table 2. Static longitudinal stability data are

presented in figures E-40 through E-43. Stick-fixed static longitudinal stability, as indicated by the variation of longitudinal control position with airspeed, was slightly positive at airspeeds greater than trim for all flight conditions tested. Correspondingly, stick-free static longitudinal stability, as indicated by the variation in longitudinal control force with airspeed, was qualitatively perceived as poor. At airspeeds less than trim, positive static longitudinal stability was noted, as indicated by increasing aft cyclic required with decreasing airspeed. Static longitudinal stability was reduced at aft longitudinal cg and was essentially neutral when trimmed at airspeeds within 5 knots of V_{NE}. The difficulty in airspeed control associated with poor control force cues will increase pilot workload during instrument meteorological conditions. The static longitudinal stability characteristics of the UH-1H helicopter with hub spring and CMRB installed are qualitatively the same as a UH-1H helicopter with STD installed and are satisfactory.

Static Lateral-Directional Stability

20. The static lateral-directional stability characteristics were evaluated in level flight at the conditions listed in table 2. Data are presented in figures E-44 and E-45. Static lateral-directional stability increased with increasing airspeed, and was independent of change in main rotor speed. The aircraft exhibited positive static directional stability at all conditions tested, as indicated by increasing left directional control with increasing right sideslip. Directional stability tended to decrease when near the left sideslip limit at 55 KCAS (maximum rate of climb airspeed), but was not discernible. The effective dihedral was positive, as indicated by increasing left lateral control with increasing left sideslip, but diminished at 55 KCAS, especially beyond 30° of sideslip, becoming neutral near the sideslip limit. Pitch change with sideslip was not noticeable. Side force, as indicated by the variation of roll attitude with sideslip, was slightly positive and increased with increasing sideslip. The gradient was very shallow at the trim airspeed of 55 KCAS, but was more positive at a trim airspeed of 105 KCAS. All control force gradients were qualitatively considered satisfactory. The static lateral-directional stability characteristics of the UH-1H helicopter with hub spring and CMRB installed are qualitatively the same as a UH-1H helicopter with STD installed and are satisfactory.

Maneuvering Flight

Maneuvering Stability:

21. Maneuvering stability was evaluated at the conditions listed in table 2. Wind-up turn maneuvers were accomplished to attain normal acceleration greater than one g and symmetrical push-over maneuvers to attain less than one g. Data are presented at a forward longitudinal cg in figures E-46 and E-47, and at an aft cg in figure E-48. The stick-fixed maneuvering stability was positive, as indicated by increasing aft cyclic control with increasing load factor, for main rotor speeds of 324 and 314 rpm at 77 KCAS, but decreased for 314 rpm when compared to 324 rpm at 97 KCAS. Maneuvering stability also decreased with increasing airspeed and/or aft movement of the longitudinal cg. Qualitatively, longitudinal control forces increased with an increase in load factor and are adequate. Main rotor flapping increased with increasing load factor, and was higher at a

forward longitudinal cg than aft for load factors greater than one. At load factors less than one, main rotor flapping was higher at an aft cg and increased with decreasing load factor. At a forward longitudinal cg, main rotor hub spring contact occurred above 1.55 g at 97 KCAS and rotor speed of 314 rpm.

22. Vibration levels were significantly higher with CMRB than with STD during wind-up turns at increased load factors (para 44). When performing turns greater than approximately 50° angle of bank with the CMRB, severe vibration levels (VRS 7 to 9) were encountered. On various occasions with the CMRB installed, recovery had to be initiated when attempting wind-up turns at 1.5 g or greater due to excessive cyclic control feedback and extreme vibration levels (VRS 10). Control feedback is defined as that condition where the capacity of the hydraulic flight control system is exceeded due to high loads in the main rotor system producing uncommanded movement in the cyclic controls. The situation was characterized by an uncommanded pitch up and an increase in airspeed, normal acceleration, main rotor flapping angle and pitch link loads (fig. E-49A and B). The onset was quick and unpredictable, requiring immediate action to regain control of the aircraft. The loss of aircraft control encountered with CMRB installed prompted AVSCOM to task AEFA to conduct additional testing with PROD CMRB (ref 4, app A) to define a maneuvering envelope. Maneuvering stability at 1.7 g was accomplished with the CMRB, but it required several attempts. Turns up to 1.7 g with STD were accomplished with significantly less effort and lower vibration levels (VRS 7). The UH-1H with hub spring and CMRB installed failed the requirement of the CIDS in that the flying qualities in maneuvering flight were degraded compared to a UH-1H with STD installed. The maneuvering stability of the UH-1H helicopter with hub spring and CMRB installed is satisfactory though degraded when operating at a main rotor speed of 314 rpm.

Maneuvering Envelope:

23. The objective of this additional testing was to define the condition within the test envelope where control feedback occurs. Testing was conducted with PROD CMRB, STD, and CMRB. Maneuvering envelope testing was accomplished utilizing the wind-up turn method for increasing load factor, power ON and power OFF (autorotation), at the conditions specified in table 2. Power ON test points included the airspeed range from minimum power required to V_{NE} minus five knots, and power OFF airspeeds were that for minimum rate of descent, maximum glide distance and that recommended by the Aircrew Training Manual (ATM) (ref 15). At each condition, the aircraft was first stabilized in ball-centered level flight. The roll attitude and load factor were then slowly increased up to the limit, with airspeed and collective held constant. The test was repeated using a more rapid increase in roll attitude and load factor. The limit was defined as the load factor limit imposed by the airworthiness release (fig. B-3, app B) or the point at which cyclic control feedback was first evidenced, whichever occurred first. Feedback usually occurred with the STD, CMRB, and PROD CMRB outside of this test referred load factor versus airspeed envelope as depicted in figure E-50, appendix E. However, it usually did occur within the envelope (60° bank angle) published in the operator's manual (ref 6, app A), and more predominantly at a main rotor speed of 314 rpm. While conducting maneuvering stability testing with CMRB, loss of aircraft

control was experienced (para 22). The maneuver was repeated at the same conditions with PROD CMRB (fig. E-51A and B, app E) producing similar aircraft response. However, because proficiency had been gained, the pilot was able to approach the maneuver more carefully enabling recovery upon initially encountering the onset of control feedback without the loss of aircraft control. The pilot cognizant of the possibility that aircraft control may be lost, would lower collective and reduce roll attitude, thereby trading airspeed for load factor. Although no aft longitudinal cyclic control input was applied, the aircraft still exhibited an uncommanded pitch up. With STD installed, feedback was also experienced, but no uncommanded pitch up was encountered (fig. E-52A and B). The onset of cyclic control feedback could be predicted by the progressive increase in the first harmonic vibration of the main rotor (1/rev) (para 44), warning the pilot of the increasing severity of the maneuver. Unlike the STD, the 1/rev pounding vibration and feedback associated with the CMRB usually occurred rapidly and unpredictably affording the pilot little advance warning; however, uncontrolled flight was prevented with experience gained through training. The 1/rev vibration levels associated with CMRB and PROD CMRB are much higher than that of the STD (para 44). The effectiveness of the UH-1H helicopter to conduct maneuvering flight with hub spring and CMRB installed will be limited, due to the extreme vibration levels and the possibility of temporarily encountering uncontrollable flight, and is a deficiency. Hydraulic control system loads were comparable in maneuvering flight for the CMRB, PROD CMRB and STD (para 45). The onset of control feedback occurred at similar aircraft weight, load factor, airspeed and density altitude combinations for CMRB, PROD CMRB and STD with an increased chance of feedback while operating at a main rotor speed of 314 rpm. The following change should be made to chapter 8 of the operator's manual.

> Increasing bank angles up to the limit will induce correspondingly increasing 1/rev and 2/rev vibration levels. As the bank angle limit of the aircraft is approached, the 2/rev vibration increase will be the first and most notable vibration. As the bank angle is further increased, a sudden increase in the 1/rev vibration will occur. This 1/rev vibration will have a vertical pounding characteristic. A slight increase in the bank angle beyond this point could result in saturation of the flight control system and control feedback. Any further increase in bank angle could result in loss of aircraft control. The aircraft's bank angle limit can be reached at the lighter gross weights before encountering the 1/rev vertical vibration; however, as gross weight is increased, the above condition (1/rev pounding and feedback) will occur at reduced bank angles.

WARNING

Abrupt rolling maneuvers coupled with aft cyclic inputs which induce a high pitch rate, must not be continued beyond the point of significantly increased 1/rev vibration onset. If notably increased 1/rev vibrations occur during maneuvering flight, the severity of the maneuver must be reduced or control feedback and loss of aircraft control may result.

24. While conducting a 180° turn to an autorotational landing with CMRB installed, a similar aircraft reaction and loss of aircraft control was experienced (fig. E-53A and B, and para 43) as that witnessed during power ON flight. Maneuvering envelope testing with power OFF in autorotation indicated the hydraulic control system could be saturated, causing control feedback with possible loss of aircraft control, at similar conditions encountered power ON. Wind-up turns with power OFF and PROD CMRB installed were also characterized by large main rotor speed excursions of approximately ±10 rpm (fig. E-54A and B), creating a situation where the potential for loss of aircraft control is increased due to divided pilot attention (increased workload). Similar maneuvers with STD installed required minimal pilot compensation to maintain rotor speed (fig. E-55A and B), and correspondingly reduced workload producing a more controlled situation. Additional training should be given to all utility helicopter pilots that will fly the UH-1H helicopter with hub spring and PROD CMRB installed, to enable each pilot to recognize the characteristics exhibited during power ON or OFF maneuvering flight.

Roll Reversals

25. Aircraft handling qualities and main rotor flapping margins were evaluated during roll reversals at the conditions presented in table 2. Roll reversals were executed at slow and moderate roll rates, at successively decreasing load factors. Utilizing a wings-level push-over technique, a load factor of less than one was generated, and a coordinated roll to a desired bank angle (maximum of 45°) to the left or right was initiated. At the desired bank angle, a roll reversal was executed. During the maneuver, the collective control was held fixed and the cyclic control was used in an attempt to maintain load factor. The aircraft was then returned to a level attitude. Representative time histories are presented in figures E-56 and E-57.

26. Roll reversal test results are presented in figures E-58 and E-59. Conditions of decreasing normal acceleration, as well as increasing pitch and roll acceleration, resulted in an increase of main rotor flapping. Assuming a constant normal acceleration, main rotor flapping was independent of variations in main rotor speed (314 and 324 rpm) and airspeeds (75 and 95 KCAS). A roll reversal executed at the envelope minimum test load factor of 0.75 at 95 KCAS produced main rotor flapping sufficient to encounter the hub spring at a roll acceleration of 70 deg/sec^2. Cues of hub spring contact were characterized by a single, low amplitude pounding through the airframe which was accompanied by a moderately damped, low frequency feedback through the cyclic control. This cyclic control feedback was in both the longitudinal and lateral axes.

Extrapolation of the fairing at a constant normal acceleration of 0.75 g indicates main rotor flapping of 100% (mast bumping) will occur at a roll acceleration of approximately 135 deg/sec^2. At the minimum allowable load factor of 0.50 recommended in the operator's manual (ref 6, app A), a roll acceleration of approximately 45 deg/sec^2 will produce hub spring contact, while extrapolation indicated that a roll acceleration of less than approximately 90 deg/sec^2 would result in mast bumping.

27. Overall assessment of roll reversals indicated that main rotor flapping versus roll acceleration gradient increased with increasing roll acceleration, with the greatest main rotor flapping occurring upon recovery from the reversal. Pitch link loads increased during the recoveries, particularly at higher airspeeds and at a main rotor speed of 314 rpm, and appeared to be a function of pitch rate. Reversals of moderate roll rates generally produced hub spring contact, but were accomplished satisfactory with the hub spring and CMRB installed.

Dynamic Stability

28. Short-period and long-term dynamic stability was evaluated during level flight, maximum power climb and autorotational descent at the conditions listed in table 2.

29. Dynamic stability was generally heavily damped in all axes in level flight and autorotation. However, during maximum power climb aircraft response was divergent in the longitudinal axis (aperiodic divergent or divergent after one oscillation) (fig. E-60, app E). During static longitudinal stability testing in maximum power climb at 50 KCAS, while trimmed at 55 KCAS, an instability about all three axes was encountered (fig. E-61). At these conditions near the airspeed for maximum rate of climb, the short-period response was essentially neutrally damped about the pitch, roll and yaw axes. The long-term response was neutral to divergent in the pitch axis. These characteristics caused difficulty in stabilizing at a desired airspeed at rates of climb above 500 ft/min requiring considerable pilot compensation to maintain airspeed within $\pm$4 knots, and is a shortcoming. This instability appeared similar to that reported in reference 10, appendix A with STD installed. While attempting to stabilize near the right sideslip limit of 41°, at 55 KCAS and main rotor speed of 314 rpm, a neutrally damped oscillation (approximately 5 second period) was encountered requiring considerable pilot compensation to maintain sideslip angle within $\pm$3°, yaw attitude within $\pm$3° and pitch attitude within $\pm$2°. The dynamic stability characteristics of the UH-1H helicopter with hub spring and CMRB installed were independent of rotor speed but deteriorated with movement of the cg aft during maximum power climb. The dynamic stability characteristics are satisfactory.

Controllability

30. Longitudinal, lateral and directional control power (aircraft attitude displacement per inch control displacement in a given time), response (angular rate per inch control displacement) and sensitivity (angular acceleration per inch control displacement) characteristics were evaluated during hover, level flight, maximum power climb, autorotational descent and low speed flight at critical azimuth and airspeed in 1 g flight at

the conditions listed in table 2. Hub spring contact rarely occurred for inputs up to one inch regardless of flight condition.

31. Results of the longitudinal controllability testing are presented in figures E-62 through E-65, appendix E. Longitudinal controllability was generally independent of airspeed, flight condition or direction of input for a specific longitudinal cg, but decreased with forward movement of the cg. Forward step inputs of magnitude greater than approximately one-half inch during maximum power climb required recovery prior to achieving a maximum pitch rate to prevent exceeding the minimum allowable load factor limit of 0.5 (fig. E-66). During autorotation, an aft longitudinal step input of less than one inch produced an increase in normal acceleration and main rotor speed requiring collective application within two and one-half seconds to prevent an overspeed (fig. E-67). Longitudinal controllability characteristics of the UH-1H helicopter with hub spring and CMRB installed are satisfactory, although load factor or rotor speed limits can be exceeded inadvertently in climb or autorotation.

32. Results of the lateral controllability testing are presented in figures E-68 through E-71. Lateral controllability was similar in hover and forward flight except for inputs greater than one inch at 96 KCAS at a forward longitudinal cg, where control response increased unpredictably to the right and was disconcerting to the pilot. Control response increased in maximum power climbs and decreased in autorotation. Some control cross-coupling associated with lateral inputs was noted in the longitudinal and directional axes during hover, maximum power climb and autorotation, but was generally considered satisfactory. Lateral controllability characteristics of the UH-1H helicopter with hub spring and CMRB installed are satisfactory.

33. Results of the directional controllability testing are presented in figures E-72 through E-76. Directional controllability in level flight was essentially independent of airspeed for a specific longitudinal cg, though higher for right inputs. Directional controllability increased with forward movement of the cg, and appeared independent of rotor speed. Directional control response was greater in hover and autorotation than in level flight or maximum power climb. Minor cross-coupling associated with directional inputs was noted in the longitudinal and lateral axes in hover and level flight, but was considered satisfactory. Cross-coupling associated with directional inputs in maximum power climb and autorotation usually were characterized by an initial roll in the opposite direction followed by a roll into the direction of the input and a nose down pitch (fig. E-77). Directional controllability while hovering in wind at selected conditions, where limited by less than 10% control margin remaining or large pedal control excursions within 10% of the stop existed, is depicted in figure E-73 for main rotor speed of 314 rpm. Dashed lines represent directional controllability while hovering in still air as comparison. Application of remaining directional control in the critical direction relative to the wind produced adequate control power, but conditions were less stringent than required by MIL-H-8501A (ref 11, app A). Directional controllability characteristics of the UH-1H helicopter with hub spring and CMRB installed are satisfactory.

Low Speed Flight Characteristics

34. Low speed flight characteristics were evaluated at the conditions shown in table 2. Results of testing at three different density altitudes at a main rotor speed of 314 rpm are summarized in figures E-78 through E-80, appendix E denoting control margins throughout the 360° relative wind azimuth. Low speed flight data are presented in figures E-81 through E-104. Control excursions and attitude variations are included for forward, rearward and sideward azimuths to indicate pilot compensation required at the test conditions.

35. Discontinuities of control position with airspeed for longitudinal control in forward and rearward flight and directional control in sideward flight were not objectionable. However, the large change in control requirement and increased control excursions between approximately 5 and 15 KTAS in rearward flight and beyond approximately 10 KTAS in left sideward flight increased pilot workload. The variation of lateral control position during right sideward flight (increasing right lateral cyclic control with increasing right sideward airspeed) and essentially no change in lateral cyclic control required with increasing airspeed in left sideward flight was conventional. Directional control was adequate at lower density altitudes though control excursions were evident at a main rotor speed of 314 rpm. As density altitude increased, there was an increase in frequency and magnitude of directional control excursions and a decrease in directional control margin while operating at a rotor speed of 314 rpm, compared to 324 rpm (fig. 6). When compared to a UH-1H with STD installed at a main rotor speed of 324 rpm, the CMRB exhibits similar directional control margins in sideward flight (fig. 6). At higher density altitudes, directional control requirements and/or excursions changed rapidly with airspeed or azimuth (fig. 7). Above 15 KTAS in right sideward flight, the requirement for directional control suddenly increased at a rotor speed of 314 rpm and aircraft heading could not be maintained due to inadequate control margin (fig. 7). This apparent lack of tail rotor effectiveness at a rotor speed of 314 rpm is also indicated in figures E-78 through E-80 by the close proximity of the 10 and 15% control margin lines at the higher density altitudes. The directional control margin increased for the conditions of figure 7 at a main rotor speed of 324 rpm and appeared to provide improved handling characteristics. The longitudinal control margins decreased to within 10% at all altitudes but were considered satisfactory. At a lateral cg up to 4 in. left of center, directional control margin was essentially unchanged from that of a mid lateral cg in right sideward flight though an increase in right lateral control position was necessary. Due to the variability (gusts) in direction and magnitude of actual surface winds and larger control excursions associated with operating at a main rotor speed of 314 rpm, adherence to tolerable wind conditions summarized in figures E-78 through E-80 still may not provide adequate directional control. This increase in directional control excursions associated with hovering in actual winds was previously noted in reference 10, appendix A. When operating a UH-1H helicopter in close proximity to the ground with the hub spring and CMRB installed, a main rotor speed of 324 rpm should be utilized.

36. Vibrations and main rotor flapping were increased at relative wind azimuths between approximately 90 and 270°. At airspeeds above approximately 15 knots, main rotor hub

FIGURE 6

LOW SPEED FLIGHT CHARACTERISTICS

UH-1H USA S/N 68-16358

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	AVG SKID HEIGHT (FT)	AIRCRAFT CONFIGURATION
⊙	8650	133.5(FWD)	0.0	4320	10.0	314	13	CMRB/HUB SPRNG
△	8310	131.5(FWD)	0.0	4070	25.0	324	14	CMRB/HUB SPRNG
⊡	8600	130.2(FWD)	0.0	4080	N/A	324	15	STD

NOTES: 1. VERTICAL LINES DENOTE CONTROL EXCURSIONS
2. CONTROL EXCURSIONS UNAVAILABLE FOR STD

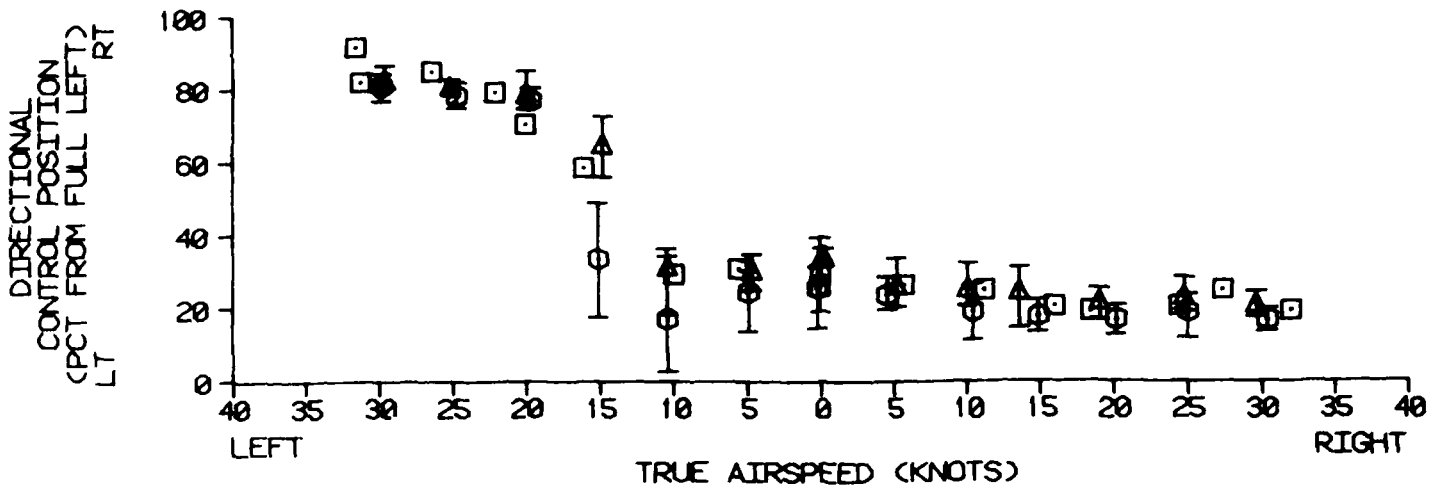


FIGURE 7

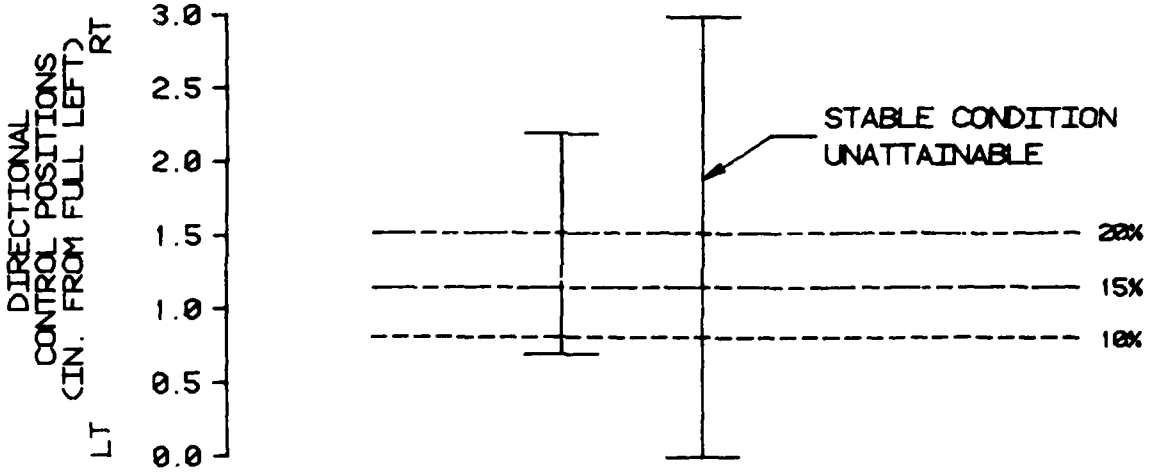
LOW SPEED FLIGHT CHARACTERISTICS

UH-1H USA S/N 68-16358

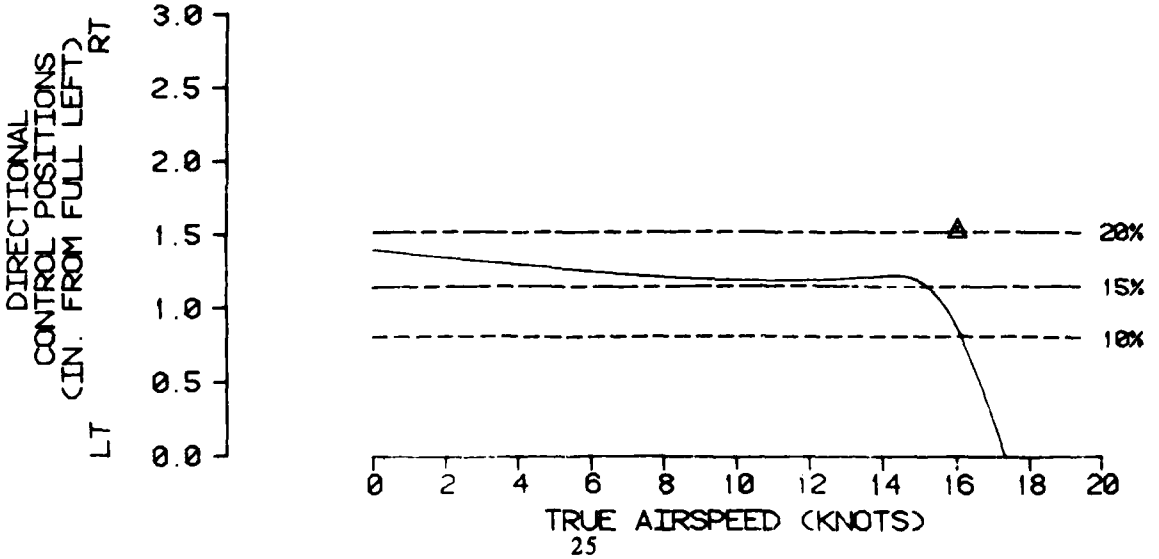
AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	AVG SKID HEIGHT (FT)	AIRCRAFT CONFIGURATION
8280	132.5(FWD)	0.0	10660	4.5	313	13	CMRB/HUB SPRNG

NOTES:
1. VERTICAL LINES DENOTE CONTROL EXCURSIONS
2. Δ DENOTES MAIN ROTOR SPEED = 324 RPM
3. TOTAL DIRECTIONAL CONTROL DISPLACEMENT = 7.7 IN.

225 DEGREE AZIMUTH



90 DEGREE AZIMUTH



spring contact produced vibration levels ranging from VRS 3 to 7, and were distinguishable from other aircraft vibrations.

Accelerations and Decelerations

37. Level accelerations and decelerations at progressively increasing rates were conducted to evaluate associated maneuvering characteristics and main rotor flapping margins, at the conditions listed in table 2. Representative time histories are presented in figures E-105 through E-109, appendix E. During forward accelerations, approximately 20° nose-down pitch attitude at a moderate rate was determined to be as aggressive as the maneuver should be performed (fig. E-105A and B). This condition required moderate pilot effort to maintain heading and altitude. When performing the same maneuver at a higher pitch rate producing a greater than 30° nose down pitch attitude, a 4 in. collective application was required to maintain altitude, which induced a rapid main rotor speed droop to 296 rpm warranting recovery of the maneuver (fig. E-106A and B). When aggressively performing right lateral accelerations to 30 KTAS and decelerations, as much as 85% main rotor flapping was experienced (figs. E-107A and B). This was perceived to be as aggressive as the maneuver should be performed due to increased vibration levels and large control inputs required during the deceleration recovery, thereby increasing pilot workload. When performing the maneuver to the left, longitudinal and directional control limits were approached, with both left and right directional control stops involved (fig. E-108 A and B). With a lateral cg 4.3 in. left of center when performing accelerations and decelerations to the left, the right directional control stop was contacted during the deceleration recovery (fig. E-109A and B). Main rotor flapping margins decrease and vibration levels increase with aggressiveness of the maneuver, but moderately aggressive accelerations and decelerations could be performed. The acceleration and deceleration characteristics of the UH-1H helicopter with hub spring and CMRB installed are satisfactory.

Aircraft System Failure

Simulated Sudden Engine Failure:

38. Simulated sudden engine failures were evaluated from level flight and maximum power climb, at the conditions listed in table 2. Representative time histories are presented in figures E-110 through E-113. Entries were initiated from ball-centered flight. Low main rotor speed was the determining factor in initiating corrective action. Recognition of engine failure occurred approximately one second after throttle reduction by the combination of left roll and left yaw response of the aircraft and activation of the low rotor speed warning light and audio tone. A delay time of 1.8 seconds was achieved at V_{NE} in level flight from an initial main rotor speed of 324 rpm at a gross weight of 8500 lb for the conditions shown in figure E-110. If the simulated sudden engine failure had been initiated from a rotor speed of 314 rpm, minimum rotor speed would have approached 260 rpm. To prevent exceeding the test transient low rotor speed limit of 275 rpm, delay time would have to be reduced by approximately one-half second which is close to the recognition time. Minimum power OFF transient low rotor speed limit is specified as 294 rpm in the operator's manual (ref 6, app A). There is not sufficient

time to recognize and react to a sudden engine failure while operating at a main rotor speed of 314 rpm with CMRB without exceeding the operational transient low rotor speed limit. However, the CMRB are very responsive to collective control changes and rotor speed recovery occurs rapidly. A delay time of 1.3 seconds did result in a minimum rotor speed of 275 rpm (though rapid collective movement produced a momentary zero g state) at an aircraft weight of 7000 lb and corresponding V_{NE} for similar flight conditions (fig. E-111, app E). Simulated sudden engine failure during a maximum power climb at the best rate of climb airspeed was characterized by severe aircraft reaction, in addition to rapid main rotor speed decay, further reducing delay time. A 0.6 second collective control delay time was the maximum achieved without exceeding the test minimum rotor speed limit for an approximate 1500 ft/min rate of climb (fig. E-112). With a lateral cg 4 in. left of center at a gross weight of 8500 lb for the conditions shown in figure E-113, recovery from a simulated sudden engine failure at V_{NE} required all available right cyclic control following nearly a 2 second delay. The inability to achieve a two second delay, without exceeding the minimum allowable transient low rotor speed limit at V_{NE} in level flight and in maximum power climb at 60 KCAS, fails the requirement of paragraph 3.5.5 of MIL-H-8501A.

39. Altitude loss of as much as 400 ft was sustained prior to regaining rotor speed control after a simulated sudden engine failure. During recovery, large attitude excursions in the pitch, roll and yaw axes were experienced, the severity of which depended upon flight condition and/or rate of collective reduction. Pitch and yaw attitude changes of approximately 30 and 55° respectively, occurred when initiated from a maximum power climb, and a roll attitude change of approximately 25° resulted with a lateral cg shift of 4 in. Hub spring contact occurred when recovering from a simulated sudden engine failure during maximum power climbs and level flight with the lateral cg 4 in. left of center. Main rotor flapping increased briefly to as much as 60% during initial recovery phases of both these flight test conditions.

40. Upon establishing a stabilized autorotational condition, maintaining a desired rotor speed was extremely difficult though airspeed was easily maintained. Small adjustments in collective control were constantly required as predictability of rotor response was poor resulting in rotor speed variations of approximately 15 rpm. The simulated engine failure characteristics of the UH-1H helicopter with hub spring and CMRB installed are essentially the same as a UH-1H helicopter with STD installed except for CMRB rotor speed control which requires considerable pilot compensation and is a shortcoming. The degraded flying qualities in autorotation of the UH-1H with hub spring and CMRB installed, as compared to a UH-1H with STD installed, failed the requirement of the CIDS. The following change should be made to the ATM (ref 15, app A) task 1053, Simulated Engine Failure, and task 3001, Standard Autorotation.

CAUTION

In aircraft equipped with the composite main rotor blades (CMRB), additional collective pitch application is required to maintain rotor speed during autorotational maneuvering flight. Collective must be increased simultaneously or slightly before increasing the bank angle and/or pitch rate. Rotor speed will tend to increase more rapidly and is less predictable than is characteristic of the metal main rotor blades. Additionally, larger collective applications are required to control and/or stop rotor speed increases.

The Directorate of Evaluation and Standardization (DES) should determine what specialized training is required and formulate a training plan accordingly. All utility helicopter (UH-1) simulator training should incorporate the characteristics exhibited by the PROD CMRB.

Hydraulic System Failure:

41. Hydraulic system failure characteristics were qualitatively and quantitatively evaluated at the conditions of table 2 throughout the airspeed range in level flight, during climb and autorotation at 60 KCAS and approaches to running landings. A slight nose-down pitching moment upon failure was controlled by an approximate 15 lb aft longitudinal control force. Increased right lateral control forces of the same magnitude were also noted. The increased cyclic control forces coupled with the onset of some control feedback required moderate pilot compensation to prevent pilot-induced oscillation (PIO) tendencies, causing an increase in control activity (fig. E-114, app E). Roll and yaw oscillations of approximately $\pm 2°$ magnitude and nearly a two second period developed during all flight conditions. Hydraulics OFF flight characteristics were independent of change in longitudinal cg, but a slight increase in control force, feedback and vibration (VRS 4 to 6) occurred at a main rotor speed of 314 rpm as compared to 324 rpm. The UH-1 maintenance manual (ref 16, app A) requires collective control movement sufficient to achieve engine torque pressures from 13 to 33 pounds per square inch (psi) with the hydraulic system OFF. At an aircraft weight of 8500 lb and an altitude of 10,000 ft, and engine torque pressure of 33 psi was unable to be achieved without hydraulic assist. Lowering collective to achieve the required 13 psi was attained, but it required a very high force. When operating at heavy gross weights and high altitudes, landings (touchdown or running) and go-arounds would be difficult to perform due to restricted collective control travel and do not meet the intent of paragraph 3.5.8 of MIL-H-8501A, and is a shortcoming. At lower altitudes and gross weight, collective force was lower than that of a UH-1H helicopter with STD installed. The hydraulic system failure characteristics of the UH-1H helicopter with the hub spring and CMRB installed are acceptable; however, high altitude operations could be compromised due to the high collective control force encountered without hydraulic assist thereby restricting control travel.

Autorotational Landing

42. The autorotational landing characteristics were evaluated during straight approaches and during 180° turn approaches at the conditions of table 2. Two techniques were utilized for the flare portion of the autorotation. Flares were initiated approximately 100 ft above ground level. One technique was a progressive flare, as prescribed in the ATM (ref 15), initiated by a progressive increase in pitch attitude to produce a smooth increase in deceleration to gain maximum deceleration effectiveness. During this technique, a continual cross check was maintained both outside the aircraft evaluating the deceleration as pitch attitude was increased, and inside the aircraft monitoring pertinent instruments insuring that main rotor speed was maintained within limits. The other technique was a predetermined pitch attitude flare initiated at a rate similar to that used during a progressive flare to achieve and maintain the predetermined pitch attitude to gain maximum deceleration effectiveness. During this technique, the initial concern was in attaining the predetermined pitch attitude through inside reference to the attitude indicator. Then through outside reference, the effect on deceleration was evaluated. Only after this sequence of events did an opportunity exist to check pertinent instruments inside the aircraft, including main rotor speed. Little reaction time remained after achieving the predetermined pitch attitude and evaluating the deceleration to prevent an overspeed should a rapid rotor speed buildup occur. Representative time histories are presented in figures E-115 though E-118, appendix E. When executing a straight approach to an autorotational landing, the characteristics appeared to be similar to that of a UH-1H helicopter with STD installed, in that a progressive flare is much better than selecting a predetermined attitude. When attempting to achieve a predetermined 20° flare attitude at 92 KCAS (approximate best glide airspeed) (fig. E-115A and B), a rapid increase in rotor speed occurred with CMRB before preventive action could be taken resulting in an overspeed of 5 rpm above the power OFF limit of 339 rpm. For similar conditions with STD installed, blade drag coefficient is approximately 250% greater, and this rapid rate of rotor speed buildup and subsequent overspeed condition would probably not have occurred while performing the same maneuver utilizing similar collective movement. However, the same maneuver was performed satisfactorily with CMRB utilizing a progressive flare attitude (fig. E-116A and B). A predetermined flare pitch attitude with CMRB leaves little reaction time to evaluate the situation, and the rapid main rotor speed buildup will require considerable pilot compensation to maintain aircraft control.

43. When performing a 180° turn to an autorotational landing, there is an even greater tendency for main rotor overspeed with CMRB requiring intense pilot compensation to control rotor speed. While conducting a 180° turn to an autorotational landing at 92 KCAS and attempting to tighten the turn increasing load factor to approximately 1.7, an overspeed was encountered which neither pilot anticipated and could prevent due to the rapid buildup in rotor speed (para 22 and fig. E-54A and B). The sudden upward movement in collective control in an attempt to arrest the rise in rotor speed generated an increase in load factor, flapping angle, pitch link loads, and vibration (VRS 10), resulting in cyclic control feedback and momentary loss of aircraft control. While performing the same maneuver under similar conditions, anticipation of the rapid increase in main rotor speed through advanced collective application curtailed an overspeed and minimized

excursions (fig. E-117A and B). When not anticipated, excursions doubled in magnitude with chances of an overspeed increased (fig. E-118A and B). The autorotational landing characteristics of the UH-1H helicopter with the hub spring and CMRB or PROD CMRB are similar to that of a UH-1H helicopter with STD installed with the exception of increased pilot workload required to control main rotor speed. While conducting approaches to an autorotational landing with CMRB, the recommended CAUTION of paragraph 40 concerning timing and magnitude of collective application should be utilized. A DES instructor pilot given the opportunity to attempt a 180° turn to an autorotational landing required four attempts before accomplishing a safe landing on a 300 foot training site. The increased pilot workload required to control rotor speed of CMRB or PROD CMRB installed on a UH-1H helicopter during an autorotational landing is a deficiency. However, with the recommended additional training of paragraph 40 given to all utility helicopter pilots, workload can be reduced to allow safe autorotational landings.

STRUCTURAL DYNAMICS

Vibration

44. The vibration characteristics were qualitatively evaluated throughout the test program, and quantitatively evaluated in hover, level flight and maneuvering (wind-up turns) flight at constant power at the conditions listed in table 2. Vibration accelerometers were installed on the floor at the pilot and copilot seats and near the aircraft cg as noted in appendix C. Data are presented in figures E-119 through E-151 and are grouped in order of blade type, flight condition, location (pilot, copilot, cg) and accelerometer axis (vertical, lateral, longitudinal). Representative CMRB and STD 2/rev vertical vibration data and associated pilot and copilot assessment in level and maneuvering flight are presented in figures E-119 through E-126. Vibration amplitudes for both CMRB and STD increased with airspeed and normal acceleration. Vibration levels in hover, level flight (especially above 80 KCAS) and during maneuvering flight at constant power were significantly higher with CMRB than with STD. Perceived and measured vibration levels at all flight conditions were higher at the copilot station than at the pilot station. Vibration characteristics of the PROD CMRB are similar to the CMRB as represented by the fundamental and 2/rev vibration data in figures E-127 through E-131. Vertical accelerations exceeded the allowable 0.15 g limit of paragraph 3.7.1 of MIL-H-8501A for PROD CMRB or CMRB at the pilot station for airspeeds greater than 85 KCAS, and for all airspeeds at the copilot station. These levels of vibration, especially above 80 KCAS, are fatiguing and make reading flight publications very difficult. Examples of vertical, lateral and longitudinal vibratory accelerations in level flight and wind-up turns at near mission gross weight are presented for CMRB at main rotor harmonics up to 8/rev in figures E-132 through E-145. Vibration characteristics with CMRB or PROD CMRB are a shortcoming in level flight and deteriorate to a deficiency above 1.5 g in a wind-up turn. Turns greater than 50° angle of bank produce extreme vibration (VRS 7 to 9), and on occasion when cyclic control feedback was encountered, vibration levels became intolerable (VRS 10) with the sole intent of the flight crew to reduce control feedback and vibration. An increased 1/rev vibration of nearly 0.4 g at

the pilot station, evident to the flight crew as vertical pounding characteristic, precedes feedback then usually diminishes during feedback with an increased 2/rev as the prominent vibration (figs. E-148 through E-151). The increase in 1/rev pounding vibration was not a good cue since the onset is rapid and unpredictable. With STD, the increase in 1/rev vibration preceding control feedback is more progressive and less severe providing good cues that if severity of the maneuver is continued or increased, cyclic control feedback may be encountered. Vertical vibration amplitudes (primarily 2/rev) and perceived vibration levels increased slightly with an increase in altitude with CMRB, whereas slightly increased vibratory amplitudes with increase in gross weight were perceived by the flight crew as similar. Qualitatively, vibration levels were perceived as slightly reduced for a main rotor speed of 324 rpm when compared to 314 rpm. Further CMRB and STD vibration data obtained at additional gross weights and altitudes can be found in an interim vibration survey reported on 24 March 1987 (ref 17, app A). Vibration characteristics are similar with the PROD CMRB and CMRB, and in general vibration levels are higher than with STD which overall produced a more comfortable ride.

Structural Loads

45. Main rotor pitch link loads and cyclic and collective hydraulic flight control actuator loads were obtained during maneuvering envelope testing. Oscillatory and peak loads data for near mission gross weight at 95 KCAS is presented in figures E-152 through E-154, appendix E for both PROD CMRB and STD. Trends represented at a gross weight of 8400 lb are indicative of loads throughout the gross weight range. Main rotor pitch link oscillatory loads are generally lower with PROD CMRB installed than with STD, except when control feedback is encountered and loads associated with PROD CMRB become greater. Oscillatory pitch link loads tended to be independent of changes in main rotor speed for STD, but slightly increased for a rotor speed of 314 rpm compared to 324 rpm for CMRB. Oscillatory and peak loads were generally greater for the left cyclic control actuator than for the right actuator for PROD CMRB, opposite to that of STD. Upon encountering feedback, PROD CMRB right actuator loads increased over left which tended to remain constant. Cyclic and collective actuator loads consistently increased with load factor up to and including the regime of control feedback for STD. Overall, control loads were comparable in level and maneuvering flight for PROD CMRB, CMRB and STD.

RELIABILITY AND MAINTAINABILITY

46. Reliability and maintainability of the hub spring and CMRB installed on the UH-1H helicopter were monitored throughout the test program. The UH-1H helicopter rotor system equipped with CMRB required nearly twice as many flights to track and balance than when STD were installed, and after tracking was completed, the perceived vibration level was higher with CMRB than with STD. A new tracking procedure was provided by BHTI for the CMRB; however, this procedure did not reduce the number of flights required to track the CMRB, nor did it produce a smoother flying aircraft as perceived by the flight crew. Overall, the UH-1H with CMRB installed produced a less comfortable

ride than the STD, especially above 80 KCAS, and will increase pilot fatigue. The increased maintenance time required to track and balance the CMRB with hub spring installed is a shortcoming which should be corrected prior to production. Track and balance of a set of PROD CMRB indicated reduced maintenance times similar to that of STD, though ride quality remained unchanged and degraded compared to STD.

47. Numerous voids in the bonding of the leading edge abrasion strip on the CMRB developed throughout the test program. Repair required 24 to 48 hours to cure. The excessive time required to repair voids attaching the leading edge abrasion strip to the CMRB is a shortcoming that should be alleviated prior to production.

48. After initial replacement and installation of the CMRB, the main rotor blade retaining bolts lost their initial preset torque after 15 to 25 flight hours. A change should be made to the UH-1H maintenance manual requiring retorquing of the main rotor retaining bolt 15 flight hours after initial blade installation.

49. Adjustment of the tension torsion straps required nearly an hour to complete due to the installation of the main rotor hub spring assembly, an increase of over twice the previous maintenance time. The hub spring restraint plate did not allow easy access to the adjusting screw for the tension torsion straps. The difficulty of adjusting the tension torsion straps in the UH-1H helicopter with the hub spring assembly installed will increase maintenance workload and is a shortcoming which should be corrected prior to production.

50. Increased driveshaft misalignment occurred between the transmission and the engine during main rotor hub spring contact. During testing, various components in the transmission and drive system required adjustment or replacement, some of which were submitted as Test Incident Reports (TIR), and listed in appendix F. Further reliability and maintainability testing should be conducted to determine if higher drive train stresses associated with main rotor hub spring engagement will reduce the fatigue life of any component. The effect of temperature variation on the hub spring and the corresponding variation in structural loads and vibrations should also be investigated.

51. Exposure of components to prolonged higher vibration levels will reduce their fatigue life. Several components in the flight control system of the test aircraft required replacement during the test and were submitted as TIR. Failure of these components cannot be directly contributed to the prolonged higher vibration environment produced by the CMRB during this test, as the status of these components was unknown prior to CMRB installation. However, further reliability and maintainability testing should be conducted on a UH-1H with PROD CMRB installed to determine if the fatigue life of any component will be reduced.

AIRSPEED CALIBRATION

52. An airspeed calibration test was conducted in level flight to determine the position error of the UH-1H roof mounted airspeed system with CMRB installed. The result of

this test is presented in figure E-155, appendix E. In level flight, at an average rotor speed of 323 rpm, airspeed position error varied from -6 knots at 40 knots indicated airspeed (KIAS) to zero at 87 KIAS to +1 knot at 113 KIAS. Additional main rotor speeds of 303 and 294 rpm indicated a position error of nearly zero at 105 KIAS, which is within the data scatter connoting that airspeed position error is essentially independent of changes in rotor speed.

CONCLUSIONS

GENERAL

53. The following conclusions were reached concerning the installation of the preproduction hub spring and CMRB or PROD CMRB on the UH-1 helicopter.

a. The performance of the UH-1H has been improved over that of a UH-1H with STD installed.

b. There were no handling qualities differences noted between CMRB and PROD CMRB.

c. The handling qualities of the CMRB and PROD CMRB were qualitatively similar to STD except for greater difficulty in controlling rotor speed, especially during autorotation, and greater probability of loss of aircraft control at increased load factors.

d. The maneuvering envelope was similar for CMRB, PROD CMRB and STD, but generally less than the UH-1H operational envelope.

e. Most maneuvering can be performed in a moderately aggressive manner with adequate flapping margins remaining. Adequate cues exist, to alert a pilot experienced in operation of a UH-1H with CMRB installed, of hub spring contact.

f. The vibration characteristics are similar for the CMRB and the PROD CMRB, and degraded compared to STD.

g. There were two deficiencies, seven shortcomings, five CIDS noncompliances, three military specification MIL-H-8501A noncompliances, and one possible MIL-H-8501A noncompliance identified.

DEFICIENCIES

54. The following deficiencies were identified concerning the installation of the preproduction hub spring and CMRB or PROD CMRB on the UH-1H helicopter, and are listed in decreasing order of relative importance.

a. The increased pilot workload required to control rotor speed affecting safe autorotational landing (para 43).

b. The limited effectiveness of the UH-1H helicopter to conduct maneuvering flight due to extreme to intolerable vibration levels above 1.5 g and the possibility of temporary loss of aircraft control (paras 23 and 44).

SHORTCOMINGS

55. The following shortcomings were identified concerning the installation of the preproduction hub spring and CMRB or PROD CMRB on the UH-1H helicopter, and are listed in decreasing order of relative importance.

a. Considerable pilot compensation to control rotor speed following a simulated sudden engine failure (para 40).

b. The high collective control force, as a result of loss of hydraulic assist, restricting control travel and affecting landing at heavy gross weights and high altitudes (para 41).

c. The high vibrations in level flight (para 44).

d. The increased maintenance time required to track and balance the main rotor system (para 46).

e. The difficulty of adjusting the tension torsion straps will increase maintenance workload (para 49).

f. The excessive time required to repair voids attaching the leading edge abrasion strip to the CMRB (para 47).

g. The instability in all three axes encountered during maximum power climb near airspeeds for maximum rate of climb, requiring considerable pilot compensation to maintain airspeed ± 4 knots (para 29).

SPECIFICATION COMPLIANCE

56. The UH-1H helicopter with preproduction hub spring and CMRB or PROD CMRB installed failed to meet the following requirements of the CIDS.

a. Paragraph 3.2.1.1.1 – Failed the OGE hover performance required improvement of 6.0% for the CMRB compared to STD at a pressure altitude of 4000 ft and temperature of 35°C with an improvement of only 2.4% (para 9).

b. Paragraph 3.2.1.1.1 – Failed the OGE hover performance required improvement of 6.0% for the PROD CMRB compared to STD at a pressure altitude of 4000 ft and temperature of 35°C with an improvement of only 4.6% (para 9).

c. Paragraph 3.2.1.1.1 – Failed the required fuel flow decrease of 5.1% in level flight for the PROD CMRB compared to STD at a pressure altitude of 4000 ft and temperature of 35°C with a decrease of only 4 0% (para 15).

d. Paragraph 3.2.1.1.2 – Failed the required fuel flow decrease of 8.5% in level flight for the PROD CMRB compared to STD at sea level standard day conditions with a decrease of only 7.0% (para 15).

e. Paragraph 3.2.1.2 – Flying qualities were degraded at high load factors and in autorotation when compared to a UH-1H with STD installed (paras 22 and 40).

57. The UH-1H helicopter with preproduction hub spring and CMRB or PROD CMRB installed failed to meet the following significant requirements of MIL-H-8501A.

a. Paragraph 3.5.5 – A two second delay could not be achieved at V_{NE} in level flight and at 60 KCAS in maximum power climb following a simulated sudden engine failure (para 38).

b. Paragraph 3.5.8 – Landings would be affected when operating at heavy gross weights and high altitudes with a hydraulic system failure (para 41).

c. Paragraph 3.7.1 – Vibration amplitudes exceeded the specified limit in level and maneuvering flight (para 44).

58. It is questionable whether or not sufficient directional control power exists to meet the requirement of paragraph 3.3.6 while hovering in winds and operating the UH-1H at a main rotor speed of 314 rpm (para 33).

RECOMMENDATIONS

59. The recommended training of paragraph 40 should be implemented to make the deficiency reported in paragraph 54a acceptable.

60. The deficiency reported in paragraph 54b should be corrected prior to operational deployment of the UH-1H helicopter with CMRB and hub spring installed.

61. The shortcomings reported in paragraph 55a through g should be corrected as soon as possible.

62. The following **WARNING** should be added to chapter 8 of the operator's manual (ref 6, app A) (para 23).

WARNING

Abrupt rolling maneuvers coupled with aft cyclic inputs which induce a high pitch rate, must not be continued beyond the point of significantly increased 1/rev vibration onset. If notably increased 1/rev vibrations occur during maneuvering flight, the severity of the maneuver must be reduced or control feedback and loss of aircraft control may result.

63. The following **CAUTION** should be added to the ATM (ref 15) task 1053, Simulated Engine Failure and task 3001, Standard Autorotation (para 40).

CAUTION

In aircraft equipped with the composite main rotor blades (CMRB), additional collective pitch application is required to maintain rotor speed during autorotational maneuvering flight. Collective must be increased simultaneously or slightly before increasing the bank angle and/or pitch rate. Rotor speed will tend to increase more rapidly and is less predictable than is characteristic of the metal main rotor blades. Additionally, larger collective applications are required to control and/or stop rotor speed increases.

64. The following should be added to chapter 8 of the operator's manual (ref 6) (para 23).

Increasing bank angles up to the limit will induce correspondingly increasing 1/rev and 2/rev vibration levels. As the bank angle limit of the aircraft is approached, the 2/rev vibration increase will be the first and most notable vibration. As the bank angle is further increased, a sudden increase in the 1/rev vibration will occur. This 1/rev vibration will have a vertical pounding characteristic. A slight increase in the bank angle beyond this point could result in saturation of the flight control system and control feedback. Any further increase in bank angle could result in loss of aircraft control. The aircraft's bank angle limit

can be reached at the lighter gross weights before encountering the 1/rev vertical vibration; however, as gross weight is increased, the above condition (1/rev pounding and feedback) will occur at reduced bank angles.

65. A change should be made to the UH-1H maintenance manual (ref 16) requiring retorquing of the main rotor retaining bolt 15 flight hours after initial blade installation (para 48).

66. The DES should determine what specialized training is required prior to pilot qualification in a UH-1H helicopter with hub spring and PROD CMRB installed and formulate a training plan to encompass associated characteristics (paras 22, 23, 24, 31, 32, 33, 35, 37, 38, 39, 40, 41, 42, and 43).

67. Utility helicopter (UH-1H) simulator training should incorporate the characteristics exhibited by the CMRB (para 40).

68. An operational main rotor speed of 324 rpm instead of 314 rpm should be utilized for PROD CMRB (paras 23, 27, 35, 38, 41, and 44).

69. The PROD CMRB hover performance results contained in this report should be used in revising the UH-1H operator's manual (ref 6) for inclusion of PROD CMRB, and the reanalyzed fairings for STD be used to define hover performance with STD installed (para 10).

70. Level flight performance results contained in this report should be used in revising the UH-1H operator's manual (ref 6) for inclusion of PROD CMRB (para 15).

71. A main rotor speed range from 300 to 314 rpm should be utilized during autorotation at 60 KCAS to minimize affect on rate of descent (para 17).

72. Further reliability and maintainability testing should be conducted on a UH-1H with PROD CMRB installed to determine if the fatigue life of any component will be affected (paras 50 and 51).

73. The effect of temperature variation on the hub spring and the corresponding variation in structural loads and vibrations should be investigated (para 50).

APPENDIX A. REFERENCES

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3. Letter, AVSCOM, AMSAV-EA, 18 February 1987, subject: UH-1 Composite Main Rotor Blade (CMRB) Vibration Evaluation. (Additional Test Request)

4. Letter, AVSCOM, AMSAV-8, 20 April 1987, subject: Test Plan, Maneuvering Stability Boundary Test of the UH-1H With Composite Main Rotor Blade, AEFA Project No. 84-33, revision 4 June 1987. (Additional Test Request)

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15. Aircrew Training Manual, FC 1-211, *Utility Helicopter, UH-1H*, 31 July 1984.

16. Maintenance Test Flight Manual, TM 55-1520-242-MTF, *Army Model UH-1, EH-1 Helicopter*, 20 December 1985.

17. Letter, AEFA, SAVTE-TB, 24 March 1987, subject: Vibration Survey of Composite and Standard Metal Main Rotor blades Installed on UH-1H Helicopter, S/N 68-16358.

18. Final Report, AEFA Project No. 81-01-6, *Fuel Conservation Evaluation of U.S. Army Helicopters Part 6, Performance Calculator Evaluation*, July 1986.

APPENDIX B. DESCRIPTION

AIRCRAFT

1. The UH-1H is a thirteen-place, single-engine helicopter equipped with a two-bladed 48-foot diameter teetering main rotor and two-bladed pusher tail rotor with a maximum gross weight of 9500 pounds (lb). Power is provided by a Lycoming T53-L-13B free turbine engine with an uninstalled power rating of 1400 shaft horsepower (shp) at sea level standard day conditions. The power train limits the UH-1H to 1157 shp at a main rotor speed of 324 revolutions per minute (rpm). The test aircraft, UH-1H, USA S/N 68-16358, is shown in figures B-1 and 2. The aircraft empty weight, including test instrumentation, was ascertained prior to testing to be 5935 lb. Corresponding longitudinal center of gravity (cg) was at fuselage station 143.7 and lateral cg was at buttline 0.0. Total fuel capacity in a level attitude was determined to be 209 gallons from a fuel drained condition. The test aircraft configuration included some items of external instrumentation: nose mounted test boom incorporating a swiveling pitot-static tube and angle-of-attack and -sideslip vanes, ram air temperature probe, main and tail rotor slip ring assemblies, hub instrumentation and wiring harness, main rotor blade strain gauges, and telemetry and radar altimeter antennas. Further pertinent aircraft information is tabularized as follows.

Engine	T53-L-13B
Inlet (External)	Barrier filter with particle separator
Exhaust	Straight tail pipe
Drive shaft	K-Flex
Fuel System	Crashworthy
Pitot-static system	Roof mounted probe
Wire strike protection	Installed
Cargo hook	Installed for hover performance testing only
Paint	
Fuselage	IR suppressive
Rotors	Flat black
Radar detector	Installed
Antennas	
VHF navigation (OMNI)	Installed on tailboom
FM homing and COMM	Roof mounted
VHF/UHF	Roof mounted
Emergency location (Whip)	Installed on tailboom
Distance from bottom of skids to center of main rotor hub (airborne)	13.4 ft
Gear ratios	
Power turbine to output shaft	3.210526:1
Output shaft to main rotor	20.38306:1
Tail rotor to main rotor	5.108241:1
Flight limitations (test)	
Rotor speed	
Max power ON transient	331 rpm



Figure B-1. Left Front View, UH-1H Helicopter with Hub Spring and Composite Main Rotor Blades

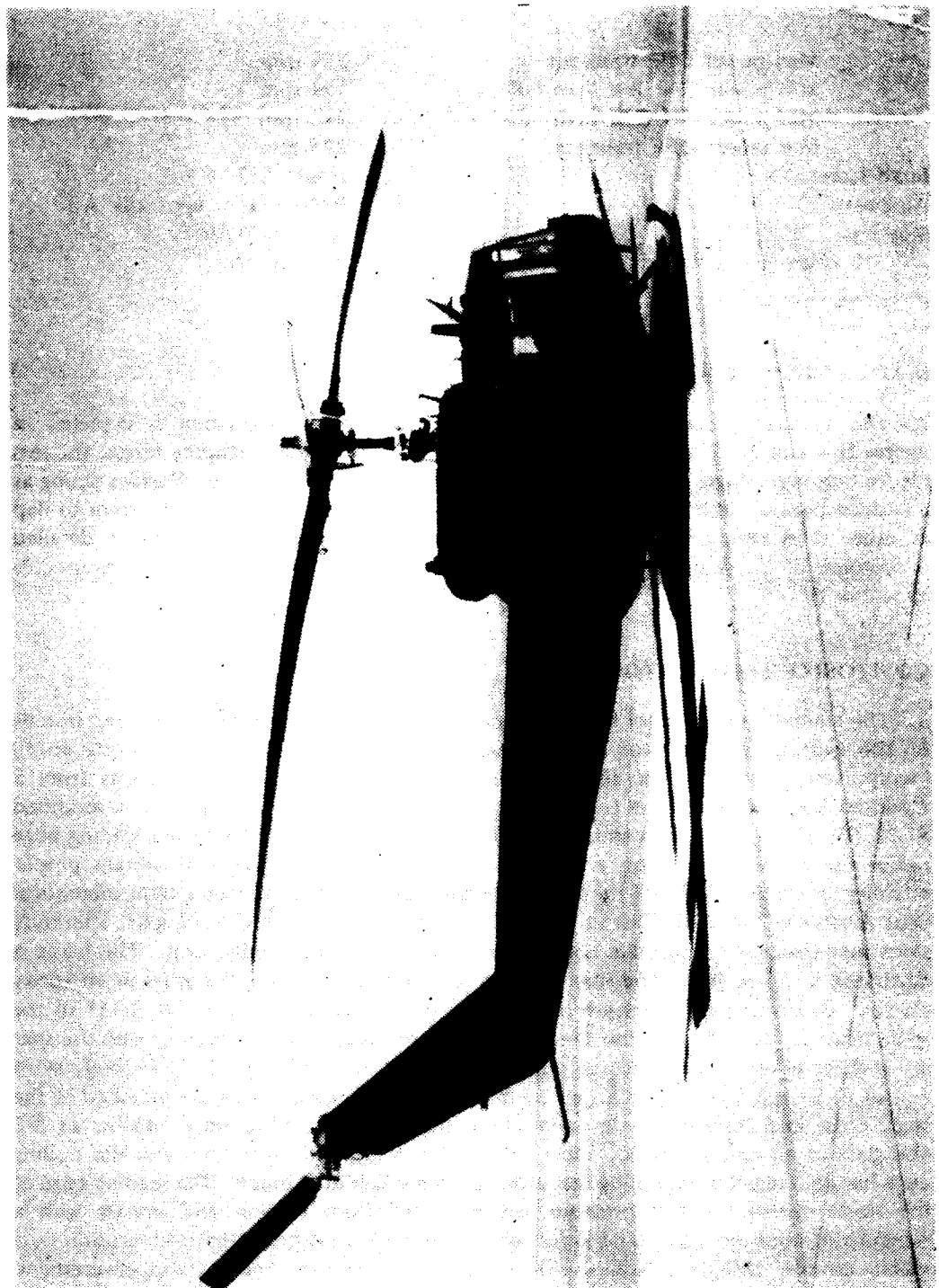


Figure B-2. Right Rear View, UH-1H Helicopter with Hub Spring and Composite Main Rotor Blades

Max power OFF transient	339 rpm
Min power ON (less than 8000 lb)	304 rpm
Min power ON (less than 7500 lb)	294 rpm
Min power OFF transient	275 rpm
Load factor	Figure B-3
Airspeed	Reference 6, appendix A
Sideslip	
50 knots true airspeed	±45 degrees(°)
V_{NE}	±15°

MAIN ROTOR HUB SPRING

2. The elastomeric preproduction main rotor hub spring installation is depicted in figures B-4 and 5. The hub is attached to the shaft by a single flapping hinge, the two blades forming a single structure, producing a see-saw flapping motion. Besides acting as a cushion between hub and mast, the intent of the hub spring is to cause the rotor to flap at other than resonance, thereby presumably reducing flapping. A more detailed description of the main rotor preproduction hub spring can be found in reference 7, appendix A.

COMPOSITE MAIN ROTOR

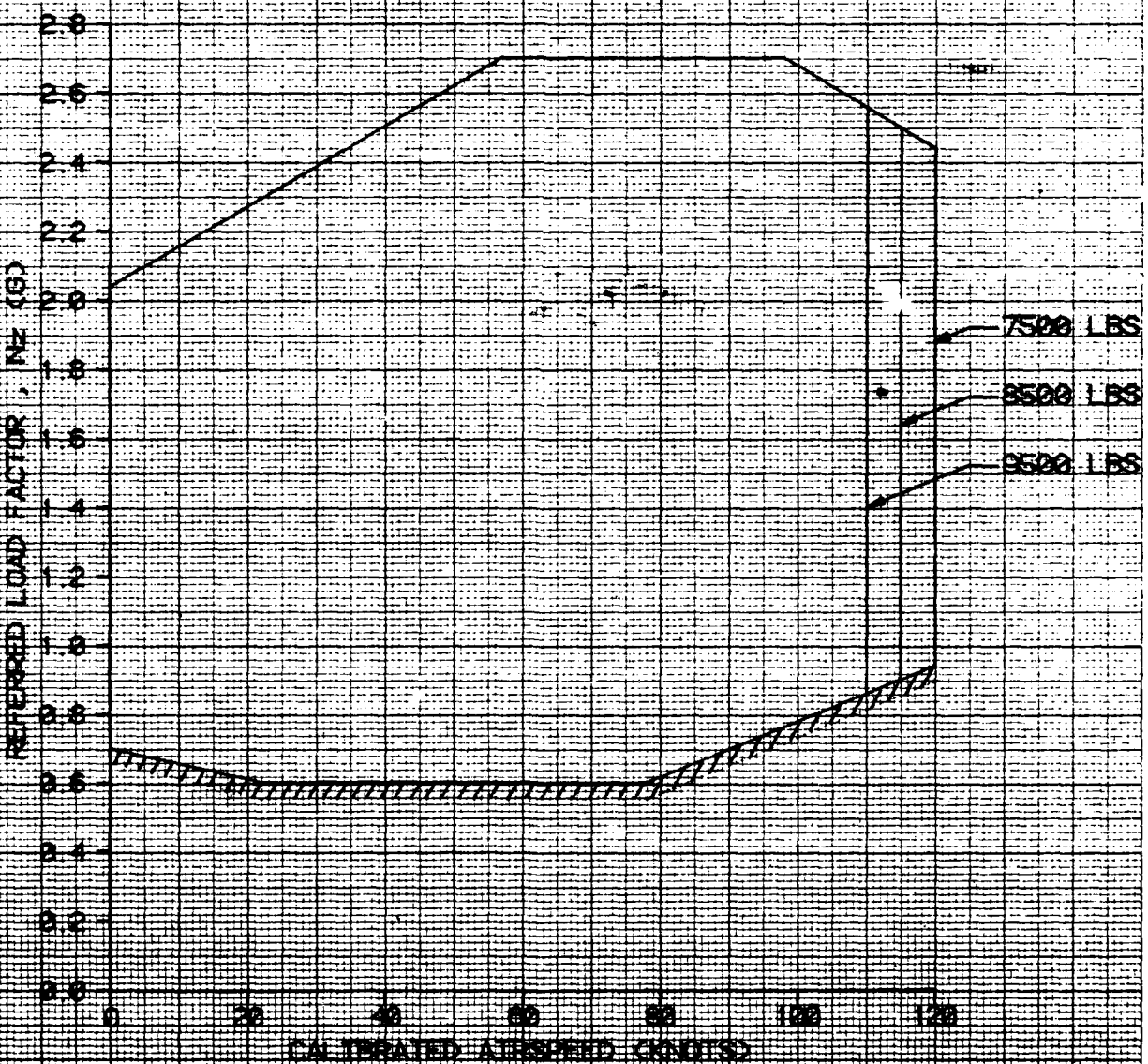
3. The composite main rotor blade incorporates filament winding technology and installs on the existing UH-1H rotor hub without change to the hub. The composite airfoil incorporates three different airfoil shapes. The composite airfoil transitions from a modified VR-7 shape at the root to a modified RC10 (B) at mid span to a modified RC08 (B) at the tip. The composite airfoil employs minor changes to the leading edge radius for erosion protection and minor changes in airfoil contour to obtain proper pitching moments. Twist of the blade is nonlinear and incorporates a total theoretical twist relative to the blade root of -10.8°. The blade consists of a front spar, afterbody skins supported by nonmetallic honeycomb core, and a trailing edge strip. The blade is illustrated in figure B-6. The spar is constructed primarily of S-2 fiberglass in an epoxy matrix. Unidirectional fibers are oriented approximately spanwise and at ±45° to the span, arranged to form a hollow D-shaped structure. Lugs wound integrally with the spar are used to attach the spar to the main bolt hole at the hub grip. The afterbody skins consist of E-type fiberglass in an epoxy matrix. The afterbody skins are attached to the spar, core, and trailing edge by adhesive bonding. The trailing edge consists of S-2 fiberglass in an epoxy matrix. Fiber orientation is primarily spanwise, and the trailing edge has an integrally wound lug that attaches to the hub drag brace. The leading edge of the blade during the test program was protected from erosion and impact with a nonmetallic abrasion strip. The lower surface near the tip is protected from erosion by a metal erosion shield. Non-shielded buried conductors and a copper-urethane conductive paint finish are incorporated to minimize lightning strike damage to the blade. Internal weights are used for section balance, dynamic tuning, and final balance for interchangeability. Primary retention of the nose block inertia weight is by adhesive bonding with mechanical entrapment providing redundancy. Actual blade planform is

FIGURE 5-3

LOAD FACTOR ENVELOPE

UH-1H USA S/N 68-16358

$$N_z = \frac{GW \times LOAD\ FACTOR}{6600 \times DENSITY\ RATIO}$$



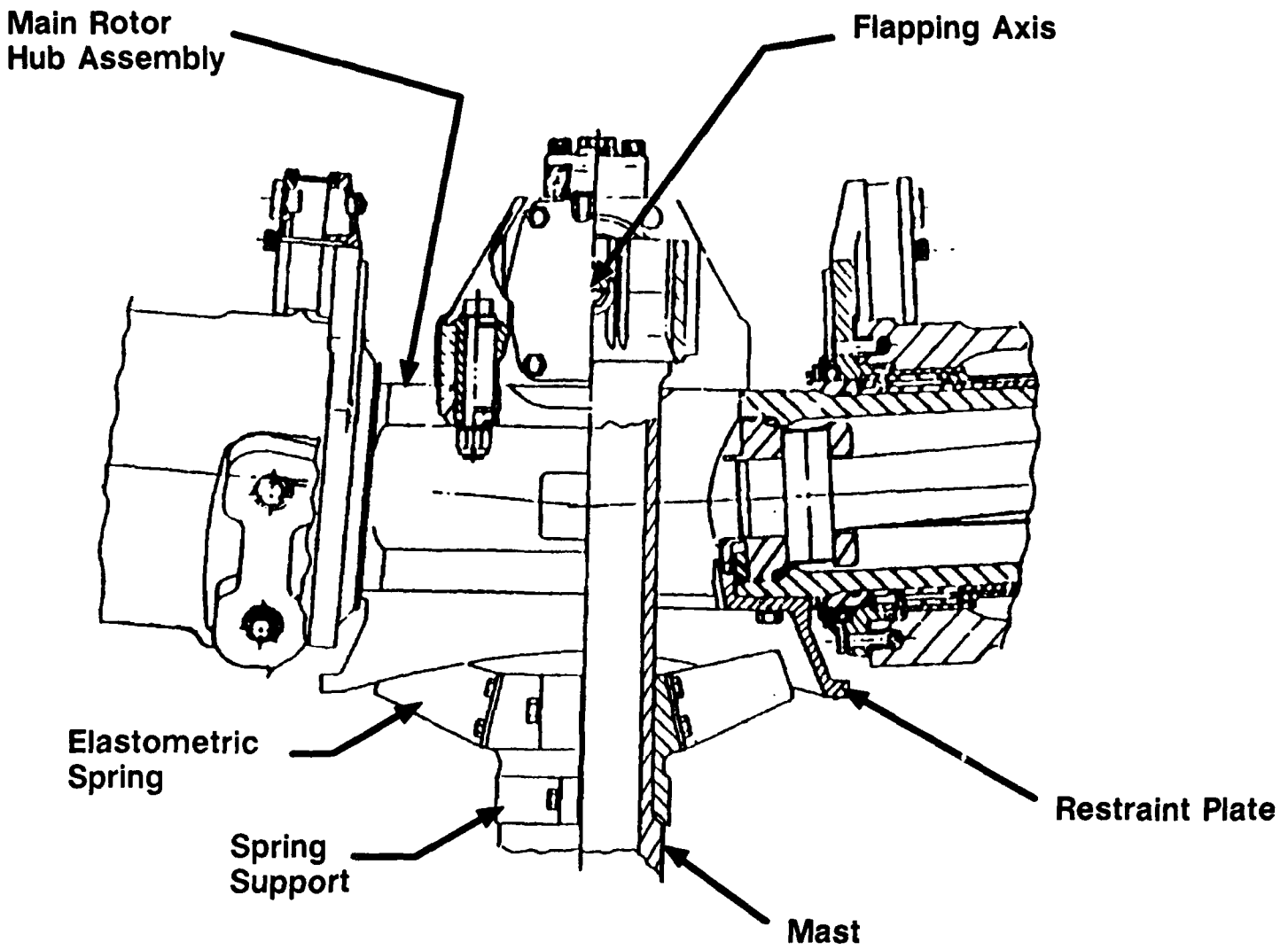


Figure B-4. UH-1H Hub Spring Modification

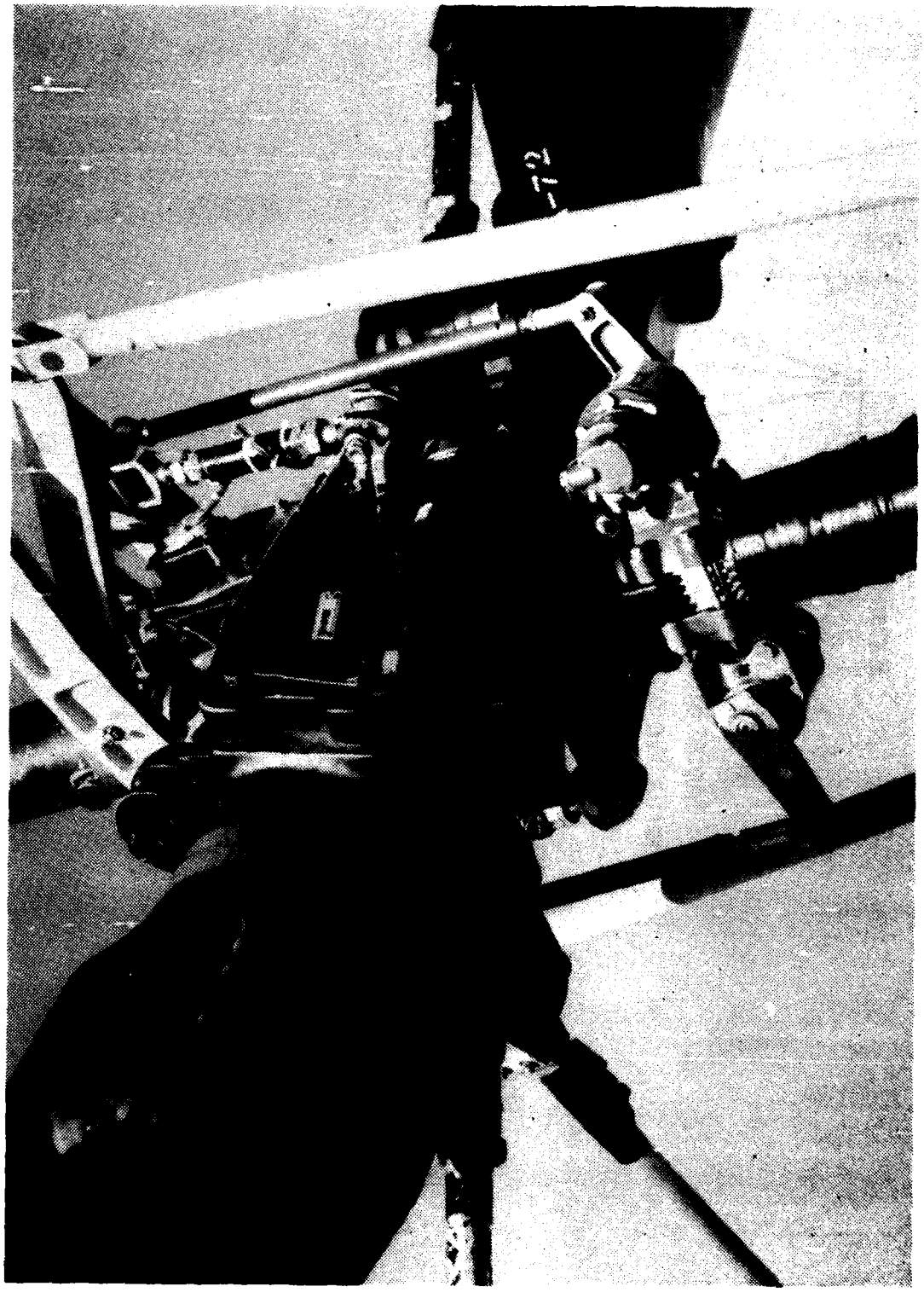


Figure B-5. UH-1H Hub Spring Installation

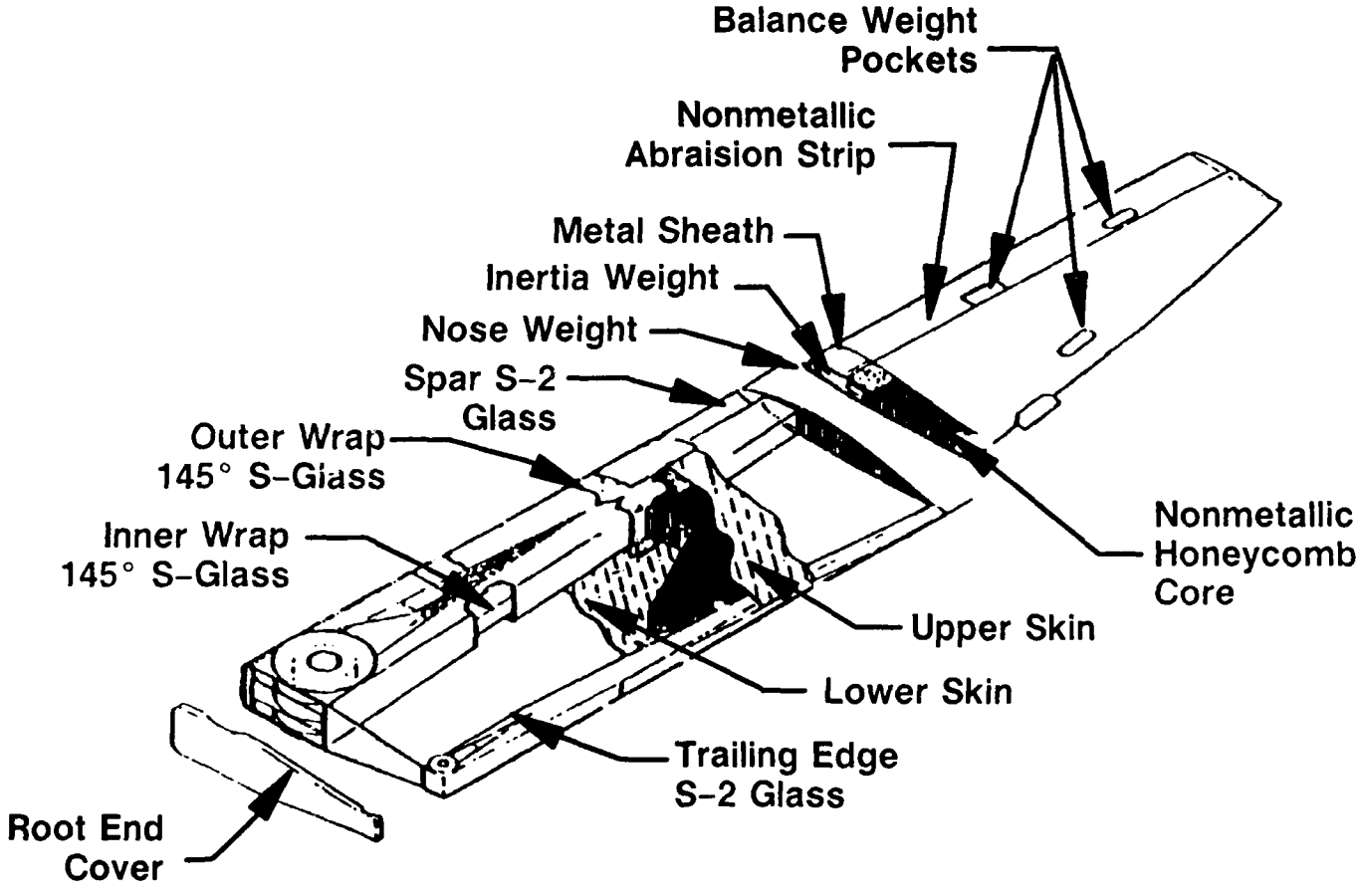


Figure B-6. UH-1H Composite Main Rotor Blade Layout

shown in figure B-7. Further pertinent composite main rotor blade and hub assembly data is tabularized as follows.

Type	Teetering
Number of blades	2
Rotor diameter (blades)	48 ft
Solidity	0.04659
Disc area	1809.56 ft^2
Blade chord–effective	21.08 in.
Blade tip chord	
Preproduction	14.5 to 14.7 in.
Production	14.75 in.
Trim tab length	
Preproduction	12 in.
Production	10 in.
Trim tab location (distance from tip)	
Preproduction	71.5 in.
Production	37.5 in.
Mast angle forward tilt	5.1°
Flapping angle range	21.9°
Swash plate (relative to mast)	
Longitudinal full forward	−11.7°
Longitudinal full aft	+11.9°
Lateral full left	−10.3°
Lateral full right	+9.9°
Control travel (measured at center of grip)	
Collective	11.3 in.
Longitudinal cyclic	12.4 in.
Lateral cyclic	12.4 in.

TAIL ROTOR

4. The tail rotor was rigged several times during the test program due to replacement of associated parts. Nominal results are tabularized as follows.

Type	Pusher
Number of blades	2
Rotor diameter	8.5 ft
Disc area	56.7 ft^2
Blade chord–constant	8.41 in.
Flapping angle range	15.4°
Blade travel range	
Pedal full left	−17.5°
Pedal full right	+8.9°
Pedal travel	7.7 in.



Figure B-7. UH-1H Composite Main Rotor Blade Planform

SYNCHRONIZED ELEVATOR

5. The synchronized elevator rigging was measured on the top (flat) surface of the right side airfoil approximately 1.5 in. from the tailboom. Results are tabularized as follows.

Span	9.5 ft
Chord	30.6 in.
Area	19.8 ft^2
Rigging	
Full forward cyclic	+4.9°
Full aft cyclic	+1.0°
Neutral cyclic	-0.6°
Maximum nose down (approximately 40 percent from full forward cyclic)	-1.6°

APPENDIX C. INSTRUMENTATION

GENERAL

1. The test instrumentation was installed, calibrated and maintained by Bell Helicopter Textron, Inc. personnel with support from the Army Engineering Flight Activity. A test boom was installed on the nose forward of the aircraft. The boom incorporated an angle-of-attack sensor, angle-of-sideslip sensor, and a swiveling pitot-static tube.

2. The data acquisition system utilized pulse code modulation (PCM) and frequency modulation (FM) encoding. The main frame rate was 250 samples/second for PCM parameters. The FM sample rate was 280 Hertz (Hz) utilizing a maximum frequency resolution of 0.27 Hz and a filter cut-off frequency of 60 Hz. Data was obtained from calibrated cockpit instruments or recorded on magnetic tape. Equipment required only for specific tests was installed when needed and is discussed in the section on special equipment.

3. Data displayed on board the aircraft include the following.

Pilot Station

Airspeed (boom)
Altitude (boom)
Altitude (radar)
Rate of climb*
Rotor speed
Engine torque
Exhaust gas temperature*
Gas producer speed*
Power turbine speed*
Control Positions
    Longitudinal
    Lateral
    Directional
    Collective
Center of gravity normal acceleration
Angle of sideslip
Pitch attitude*
Roll attitude*
Turn and slip*
Tether cable angle
Vertical speed indicator*
Event switch
Magnetic tape control switch

*Non-calibrated standard ship instrument

Engineer Station

Airspeed (ship)
Altitude*
Vertical speed indicator*
Total air temperature
Tether cable tension
Main rotor flapping
Fuel flow rate indicator
Fuel flow totalizer
Time code display
Record counter
Event switch
Magnetic tape control switch
Control fixture hardpoints

4. Data parameters recorded on board the aircraft include the following.

Digital (PCM) Data Parameters

Airspeed (boom)
Altitude (boom)
Altitude (radar)
Rotor speed
Engine torque
Total air temperature
Engine fuel flow
Engine fuel used
Gas producer speed
Power turbine speed
Tether cable tension
Tether cable angle
    Longitudinal
    Lateral
Center of gravity acceleration
    Normal
    Lateral
Angle of sideslip
Angle of attack
Control position
    Longitudinal
    Lateral
    Directional
    Collective
    Throttle

*Non-calibrated standard ship instrument

Control force**
- Longitudinal
- Lateral

Control actuator load**
- Collective
- Left
- Right

Aircraft attitude
- Pitch
- Roll
- Yaw

Aircraft angular velocity
- Pitch
- Roll
- Yaw

Main rotor torque
Main rotor flapping angle
Main rotor pitch link load
Main rotor blade bending**
- Beam (station 259)
- Chord (station 259)
- Chord (station 80)
- Torsion (station 259)

Tail rotor torque
Tail rotor flapping angle
Tail rotor blade angle
Time of day
Record counter
Event marker (pilot/engineer)

Analog (FM) Data Parameters

Vibration (accelerometers)
- Pilot seat floor
  - Vertical
  - Lateral
  - Longitudinal**
- Copilot seat floor
  - Vertical
  - Lateral**
  - Longitudinal**
- Center of gravity
  - Vertical

** Installed during maneuvering envelope testing

5. The fuselage station (FS), buttline (BL), and water line (WL) locations of the accelerometers for the measured vibrations are as follows.

	FS	BL	WL
Pilot seat floor	55	29	22
Copilot seat floor	56	-28	22
Center of gravity	139	-9	57 (transmission housing structure)

6. Provision was made for telemetry transmission of PCM parameters.

AIRSPEED CALIBRATION

7. The standard ship's and test boom airspeed systems were calibrated in level flight. The test boom pitot-static system was leak checked and the lag of the total and static chambers were balanced. The ground speed course was used to determine position error. The position error of the boom airspeed system is presented in figure C-1.

SPECIAL EQUIPMENT

Weather Station

8. A portable weather station, consisting of an anemometer, sensitive temperature gage and barometer, was used to record wind speed, wind direction, ambient temperature and pressure altitude at selected heights up to 40 feet above ground during hover and low speed tests.

Camera

9. Video and 35MM cameras were used for documentation purposes; however, no data parameters were recorded with this equipment.

Load Cell

10. A calibrated load cell incorporated with the ship's cargo hook was used during tethered hover tests. A sensitive indicator provided the engineer with cable tension, and a cable angle indicator, along with outside observers, were used by the pilot to maintain vertical alignment of the cable.

Ground Pace Vehicle

11. A vehicle utilizing a calibrated fifth wheel to determine accurate ground speed was used in conjunction with wind speed and direction to provide a precise airspeed reference for the test aircraft during low speed tests.

Control Fixtures

12. Control fixtures for longitudinal, lateral and directional controls, with associated hardpoints installed at the engineer station, were used to obtain a desired control input size during controllability and dynamic stability testing.

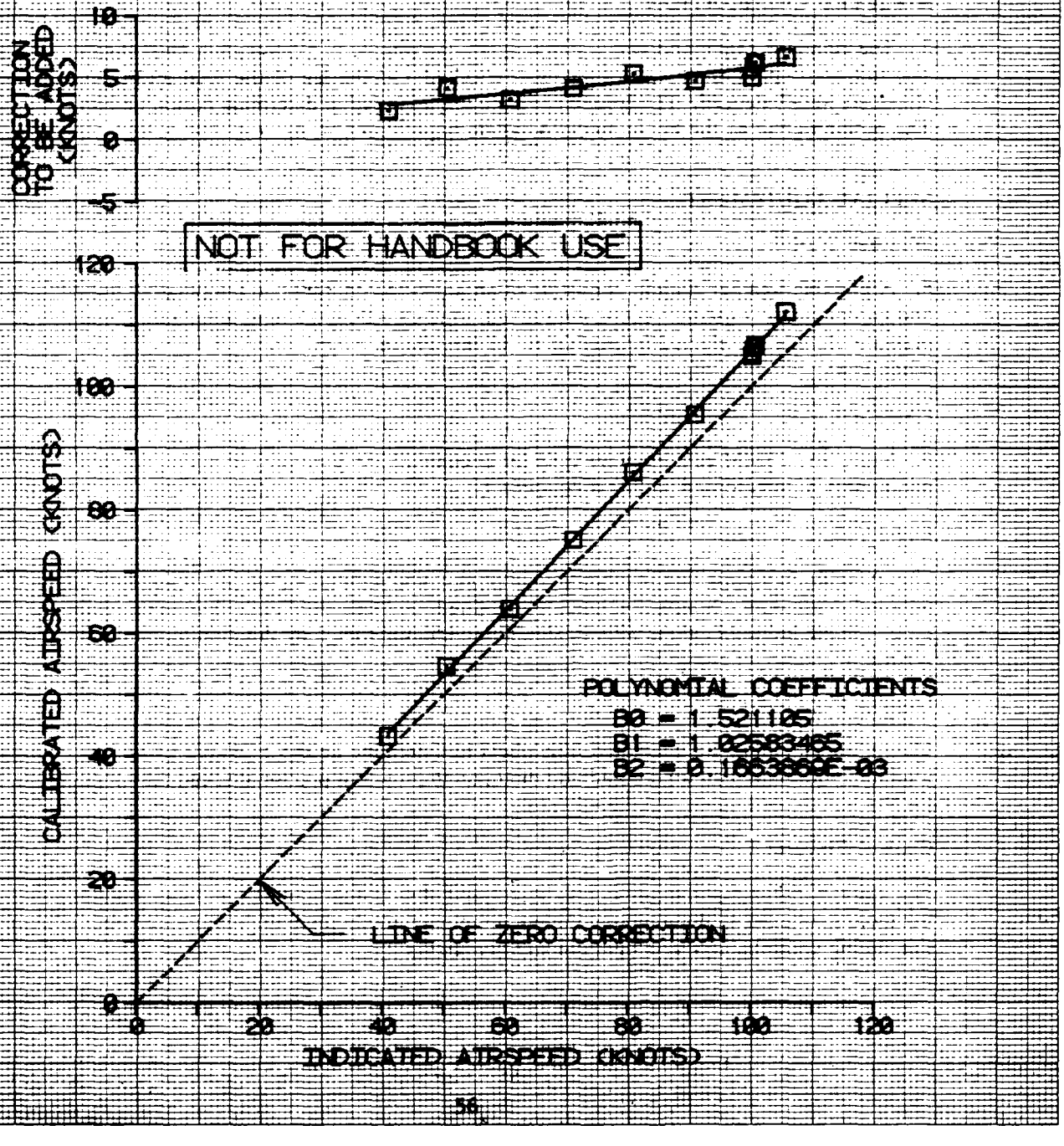
FIGURE C-1

BOOM SYSTEM AIRSPEED CALIBRATION

UH-1H USA S/N 68-16358

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION
□	7380	136.2	0.2 L	3650	22.0	323	LEVEL

NOTES:
1. MEASURED GROUND SPEED COURSE
2. CMRB/HUB SPRING CONFIGURATION
3. ⊙- DENOTES ROTOR SPEED = 300 RPM
4. A- DENOTES ROTOR SPEED = 294 RPM



APPENDIX D. TEST TECHNIQUES AND DATA ANALYSIS METHODS

GENERAL

1. Performance data were obtained using the basic methods described in Army Material Command Pamphlet AMCP 706-204 (ref 12, app A). Handling qualities data were evaluated using standard test methods described in Naval Air Test Center Flight Test Manual FTM No. 105 (ref 13).

AIRCRAFT RIGGING

2. A flight controls engineering rigging check was performed on the main and tail rotors and the synchronized elevator to insure compliance with established limits and representative handling qualities and performance information.

AIRCRAFT WEIGHT AND BALANCE

3. The aircraft was weighed in the instrumented configuration with full oil and all fuel drained prior to the start of the program. The initial weight of the aircraft was 5935 pounds (lb) with the longitudinal center of gravity (cg) located at fuselage station 143.7 and lateral cg at buttline 0.0. The fuel cells and an external sight gage were also calibrated. The measured fuel capacity using the gravity fueling method was 209 gallons. The fuel weight for each test flight was determined prior to engine start and after engine shutdown by using the external sight gage to determine the volume and measuring the specific gravity of the fuel. The calibrated cockpit fuel totalizer indicator was used during the test and at the end of each test was compared with the sight gage readings.

PERFORMANCE

General

4. Helicopter performance was generalized through the use of nondimensional coefficients as follows using the 1968 U.S. Standard Atmosphere.

a. Coefficient of Power (C_P):

$$C_P = \frac{SHP\ \ (550)}{\varrho A(\Omega R)^3} \tag{1}$$

b. Coefficient of Thrust (C_T):

$$C_T = \frac{GW + CABLE\ \ TENSION}{\varrho A(\Omega R)^2} \tag{2}$$

c. Advance Ratio (μ):

$$\mu = \frac{V_T\ (1.6878)}{\Omega R} \tag{3}$$

Where:

SHP = Engine output shaft horsepower
550 = Conversion factor (ft-lb/sec-SHP)
ϱ = Ambient air density (lb-sec^2/ft^4)
A = Main rotor disc area = 1809.56 ft^2
Ω = Main rotor angular velocity (radians/sec)
R = Main rotor radius = 24.0 ft
GW = Gross weight (lb)
CABLE TENSION = Tension of tether hover cable (lb)

V_T = True Airspeed (kt) = $\dfrac{V_E}{1.6878\sqrt{\varrho/\varrho_o}}$

1.6878 = Conversion factor (ft/sec-kt)
ϱ_o = 0.0023769 (lb-sec^2/ft^4)
V_E = Equivalent airspeed (ft/sec) =

$$\left\{\frac{7(70.7262P_{amb})}{\varrho_o}\left(\left[\left(\frac{Q_c}{P_{amb}}\right)+1\right]^{2/7}-1\right)\right\}^{1/2}$$

70.7262 = Conversion factor (lb/ft^2-in.-Hg)
P_{amb} = Ambient air pressure (in.-Hg)
Q_c = Dynamic pressure (in.-Hg)

5. Engine torque was determined using the integral production hydro-mechanical torque sensing system which provides a differential oil pressure signal proportional to the output shaft torque. The relationship between pressure and torque was determined from an engine test cell calibration. The output shp was determined from the engine's output shaft torque and rotational speed by the following equation.

$$SHP = \frac{(Q - Tare)(N_P)}{5252.113} \tag{4}$$

Where:

Q = Engine output shaft torque (ft-lb)
Tare = Average pre and post flight static Q error
N_P = Engine output shaft rotational speed (rpm)
5252.113 = conversion factor (ft-lb-rev/min-SHP)

The output shp required was corrected for the effects of test instrumentation installation by the following equation. A power loss of 0.6 horsepower was determined for electrical operation of the instrumentation.

$$SHP_0 = SHP - 0.6 \quad (5)$$

Power Available

6. Data in appendix E to be used for inclusion in the operator's manual was based on military and continuous shaft horsepower available of the T53-L-13B engine derived from the AVCO Lycoming engine specification (Deck No. 19.28.25.03). Installation losses in a hover, and other corrections were based on the conditions defined in figure 68 of AEFA Project No. 81-01-6 (ref 18). A constant 3 degree (°) inlet temperature rise, and inlet pressure based on the line fairing of figure 115 of AEFA Project No. 66-04 (ref 10) for barrier filter with particle separator installed were used for installation losses in forward flight. Engine inlet total temperature and pressure were determined by use of the following equations.

$$T_{inlet} = T_{rise} + T_{amb} \quad (6)$$

Where:

T_{inlet} = Engine inlet total temperature (°C)
°C = Centigrade degrees
T_{Rise} = 3°C
T_{amb} = Ambient air temperature (°C)

$$P_{inlet} = \left(\frac{P_{inlet}}{P_{amb}}\right) P_{amb} \quad (7)$$

Where:

P_{inlet} = Engine inlet total pressure (in.-Hg)
$\left(\frac{P_{inlet}}{P_{amb}}\right)$ = Engine inlet pressure (loss) ratio, reference 10

7. Hover guarantee compliance utilized military shaft horsepower available from figure 116 of AEFA Project No. 66-04 as required by the Composite Main Rotor Blades (CMRB) Critical Item Development Specification (CIDS). Installation losses and other corrections were also based upon this reference.

Hover Performance

8. Hover performance was obtained by the tethered hover technique. Additional free flight hover data were accumulated to verify the tethered hover data. All hover tests were conducted in winds of 3 knots or less. Tethered hover consists of restraining the helicopter to the ground by a cable in series with a load cell. Variations in C_T were attained by varying tension in the cable and rotor speed. Rotor speed was varied over the power ON operational range and to duplicate blade tip rotational mach number of

324 rpm at 35°C (referred rotor speed ($N_R/\sqrt{\theta}$) = 313.3 rpm) as required by the CIDS. Free flight hover tests consisted of stabilizing the helicopter at a desired height using the radar altimeter as a height reference. All hovering data were reduced to nondimensional parameters of C_P and C_T using equations 1 and 2, respectively, and grouped according to skid height. To obtain the out-of-ground effect (OGE) fairing for composite main rotor blades constructed from production tooling (PROD CMRB) the fairing representing CMRB was rotated down to coincide with PROD CMRB data, and is assumed representative for C_T values up through 45×10^{-4}. Summary hover capability for PROD CMRB was calculated from the nondimensional plots using power available described in paragraph 6. Data obtained in OGE hover with STD indicate an increase in power required (C_P) with an increase in main rotor speed above 314 rpm, and no change in C_P for rotor speeds below 314 rpm. A single fairing was used to represent the original UH-1H OGE hover data with standard metal main rotor blades (STD) installed, presented in figure 9 of AEFA Project No. 66-04 (ref 10), and portrays an average C_P for all rotor speeds. However, rotor speed effects noticed with this previous data were found to be similar to those observed with current STD data. Therefore, fairings of the same form used to describe OGE hover performance for STD in this analysis, were used in a reanalysis of the data presented in reference 10 to confirm variation in C_P with main rotor speed above 314 rpm.

Forward Flight Climb Performance

9. Sawtooth climbs were conducted about a mean test density altitude at various power settings resulting in various climb rates to obtain K_P data. A predetermined airspeed corresponding to minimum power required in level flight, based on preliminary level flight performance data, was determined for each test altitude. Main rotor speed was held constant during each climb, and aircraft weight allowed to vary only 500 lb to minimize correction. The effect of gross weight on climb performance was eliminated by correcting test gross weight to an average weight using the slope of the curves for each respective altitude from figure 36 of AEFA Project No. 66-04 (ref 10) by the following equation.

$$R/C_{GW\ CORR} = \left(\frac{\Delta R/C}{\Delta GW}\right)_{H_{D_{avg}}} (GW_{test} - GW_{avg}) \qquad (8)$$

Where:

$R/C_{GW_{CORR}}$ = Correction of variation in rate of climb due to change in gross weight (ft/min)

$\left(\frac{\Delta R/C}{\Delta GW}\right)_{H_{D_{avg}}}$ = Change in rate of climb for a corresponding change in gross weight based on density altitude, reference 10 (ft/min/lb) $(0.43)_{H_D = 5000\,ft}$; $(0.55)_{H_D = 10,000\,ft}$

$(GW_{test} - GW_{avg})$ = Difference between test and average gross weight (lb) $(GW_{avg} = 7700\ lb)$

Tapeline rate of climb was ascertained from pressure altitude variation with time, corrected for nonstandard temperature and referenced to density altitude.

$$R/C_{TL} = \left(\frac{\Delta HP}{\Delta t}\right)\left(\frac{T_{amb} + 273.15}{T_{STD} + 273.15}\right)_{H_P} + R/C_{GW} \tag{9}$$

Where:

R/C_{TL} = Tapeline rate of climb (ft/min)

$\left(\frac{\Delta HP}{\Delta t}\right)$ = Change in pressure altitude per unit time (ft/min)

T_{STD} = Standard ambient temperature at pressure altitude referenced to mean density altitude (°C)

Analysis of tapeline rate of climb and corresponding shp required data at each altitude and main rotor speed produced a nominal line fairing representative of all test conditions. The slope of this line fairing was used to determine a nominal K_P by the following equation.

$$K_p = \left(\frac{\Delta R/C}{\Delta SHP}\right)\left(\frac{GW_{avg}}{33,000}\right) \tag{10}$$

Where:

K_p = Power correction factor $(0.83)_{nominal}$

$\left(\frac{\Delta R/C}{\Delta SHP}\right)$ = Change in rate of climb for a corresponding change in shp required (ft/min/shp)

33,000 = Conversion factor (ft-lb/min-shp)

Level Flight Performance

10. Each flight was flown in zero sideslip flight at a predetermined C_T and $N_R/\sqrt{\theta}$. To maintain the ratio of gross weight to pressure ratio (GW/δ) constant, altitude was increased as fuel was consumed. To maintain $N_R/\sqrt{\theta}$ constant, rotor speed was decreased as temperature decreased.

Where:

N_R = Main rotor speed (rpm)

θ = Temperature ratio = $\frac{T_{amb} + 273.15}{288.15}$

δ = Pressure ratio = $\frac{P_{amb}}{P_{ao}}$

P_{ao} = 29.92126 in.-Hg

Power corrections for rate-of-climb and acceleration were determined (when applicable) by the following equations.

$$SHP_{R/C} = -\frac{(R/C_{TL})(GW)}{33,000\ (K_p)} \tag{11}$$

$$SHP_{ACCEL} = -1.6098\ x\ 10^{-4} \left(\frac{\Delta V}{\Delta t}\right)(V_T)(GW) \tag{12}$$

Where:

$1.6098\ x\ 10^{-4}$ = Conversion factor (SHP-sec/kt^2-lb)

$\left(\frac{\Delta V}{\Delta t}\right)$ = Change in airspeed per unit time (kt/sec)

Power required for level flight at the test conditions was determined using the following equation.

$$SHP_t = SHP_o + SHP_{R/C} + SHP_{ACCEL} \tag{13}$$

Test level flight data was corrected to average test conditions by the following equations.

$$SHP_s = SHP_t \frac{(\delta_s \sqrt{\theta_s}) \left[\frac{N_R}{\sqrt{\theta}}\right]_s^3}{(\delta_t \sqrt{\theta_t}) \left[\frac{N_R}{\sqrt{\theta}}\right]_t^3} \tag{14}$$

$$V_{T_s} = \left(\frac{V_T}{\sqrt{\theta}}\right)_t (\sqrt{\theta})_s \frac{\left[\frac{N_R}{\sqrt{\theta}}\right]_s}{\left[\frac{N_R}{\sqrt{\theta}}\right]_t} \tag{15}$$

Where:

Subscript t = Specific test condition
Subscript s = Average test condition

11. Data analysis was accomplished by plotting C_P versus μ for each test average C_T and $N_R/\sqrt{\theta}$. These curves were cross-plotted as C_P versus C_T for an initial determination of what effect $N_R/\sqrt{\theta}$ had at a given μ throughout the level flight envelope for both CMRB and PROD CMRB. Individual carpet plots (C_T versus C_P for a constant μ value) were

subsequently faired at each combined average $N_R/\sqrt{\theta}$ for PROD CMRB influenced by CMRB data. These carpet plots allow determination of power required as a function of airspeed for any value of C_T with reference to $N_R/\sqrt{\theta}$.

12. The specific range (SR) data were derived from the test level flight power required and fuel flow (W_{F_t}). Selected level flight performance shp and fuel flow were referred as follows.

$$SHP_{REF} = \frac{SHP_t}{\delta_I \theta_I^{\,0.587}} \tag{16}$$

$$W_{F_{REF}} = \frac{W_{F_t}}{\delta_I \theta_I^{\,0.712}} \tag{17}$$

Where:

$$\delta_I = \frac{P_{inlet}}{P_{ao}}$$

$$\theta_I = \frac{T_{inlet} + 273.15}{288.15}$$

A curve fit was subsequently applied to this referred data and was used as the basis to correct W_{F_t} to average test condition fuel flow using the following equation.

$$W_{F_s} = W_{F_t} + \Delta W_F \tag{18}$$

Where:

ΔW_F = Change in fuel flow between SHP_t and SHP_s

The following equation was used for determination of specific range.

$$SR = \frac{V_{T_s}}{W_{F_s}} \tag{19}$$

Specification Fuel Flow

13. Engine model specification fuel flow depicted on the dimensional level flight performance plots in appendix E was derived from AVCO Lycoming T53-L-13B engine deck No. 19.28.25.03. Referred specification fuel flow was plotted as a function of referred shaft horsepower at a nominal engine speed of 6500 rpm for comparison with test engine referred fuel flow obtained during this program.

14. Compliance with specified level flight CIDS requirements was determined utilizing fuel flow from figure 124 of AEFA Project No. 66-04 (ref 10). Installation losses were also based on this reference for establishing referred fuel flow.

Autorotational Descent Performance

15. Autorotational descent performance was accomplished in conjunction with climb performance testing. The tests were conducted by closing the twist grip throttle to the flight idle position and then stabilizing the aircraft on an airspeed and rotor speed. Data were acquired in zero sideslip flight at various stabilized airspeeds with constant rotor speed and a range of stabilized rotor speeds at the best rate of climb airspeed for each test density altitude based on preliminary level flight performance data. Tapeline rate of descent was ascertained from pressure altitude variation with time, corrected for nonstandard temperature and referenced to density altitude by the following equation.

$$R/D_{TL} = \left(\frac{\Delta HP}{\Delta_t}\right)\left(\frac{T_{amb} + 273.15}{T_{STD} + 273.15}\right)_{H_P} \tag{20}$$

HANDLING QUALITIES

General

16. Conventional test techniques were used during the conduct of the handling qualities tests. All tests were conducted in ball-centered flight unless otherwise noted. A brief description of all test techniques are presented in respective paragraphs of the Results and Discussion section and more detailed descriptions are contained in reference 13, and following paragraphs.

Control Positions in Trimmed Forward Flight

17. Control positions in trimmed forward flight were obtained concurrently with level flight performance testing conducted at zero sideslip. Data were obtained by stabilizing at the desired airspeed and trimming the control forces to zero in approximate 10 knot increments.

Static Longitudinal Stability

18. Static longitudinal stability characteristics were obtained by first trimming the aircraft at the desired airspeed and securing collective control in that position, except during autorotation when the collective was moved slightly to control main rotor speed throughout the descent. Airspeed was then varied $\pm$20 knots about trim in 5 knot increments utilizing the cyclic and directional controls, and letting altitude vary as necessary.

Static Lateral-Directional Stability

19. The static lateral-directional stability characteristics were evaluated by first trimming the aircraft at the desired airspeed and securing collective control. Data were obtained by

incrementally varying sideslip angle (left and right) to the maximum allowable, holding airspeed and aircraft heading constant and letting altitude vary as necessary.

Maneuvering Stability

20. Maneuvering stability was evaluated through wind-up turn and symmetrical push-over maneuvers. Wind-up turns were accomplished by initially stabilizing in level flight at the trim airspeed, then incrementally increasing normal acceleration to the maximum allowable by increasing bank angle in left and right turns while maintaining collective control position constant. Symmetrical push-overs were accomplished to attain load factors less than one by initially stabilizing in level flight at the desired airspeed, trimming control forces to zero. To initiate the push-over, the aircraft was slightly accelerated from the trim airspeed using cyclic only while maintaining constant power and trim setting. The aircraft was then decelerated, and as the trim airspeed was approached, an increment of forward cyclic control was input so that the desired load factor occurred when passing through a level attitude at the trim airspeed.

Maneuvering Envelope

21. Maneuvering envelope testing was accomplished utilizing the wind-up turn method for increasing load factor, power ON and OFF (autorotation). The aircraft was first stabilized in level flight, then roll attitude and load factor were slowly increased up to the limit, with airspeed and collective held constant. The test was repeated using a more rapid increase in roll attitude and load factor. The limit was defined as the load factor limit for the condition as defined by the test envelope of the airworthiness release (fig. B-3, app B) or the point at which cyclic control feedback was first evidenced, whichever occurred first.

Roll Reversals

22. Roll reversals were executed at slow and moderate roll rates, at successively decreasing load factors. Utilizing a wings-level push-over technique, a load factor of less than one was generated, and a coordinated roll to a desired bank angle (maximum of 45°) to the left or right was initiated. At the desired bank angle, a roll in the opposite direction was executed. During the maneuver, the collective control was held fixed and the cyclic control was used to maintain load factor. The aircraft was then returned to a level attitude.

Dynamic Stability

23. The short-period dynamic stability characteristics were obtained by recording aircraft motions that resulted from pulse-type control inputs about the longitudinal, lateral and directional axes. Each input was accomplished by rapidly displacing the particular control approximately 1 inch from trim, holding for approximately one-half second, then rapidly returning to the trim position. Following the input, all controls were held fixed until aircraft motions were damped or recovery became necessary. Releases form steady heading sideslip were also accomplished to aid in the evaluation of the dynamic lateral-directional stability characteristics. With the aircraft in a sideslip, the controls were returned to trim and held until aircraft motions were damped. The

longitudinal long-term dynamic response was obtained by displacing the aircraft approximately 10 knots from the trim airspeed using longitudinal cyclic and then returning the control to the trim position. Following the input, all controls were held fixed until aircraft motions were damped or recovery became necessary.

Controllability

24. Longitudinal, lateral and directional control power (aircraft attitude displacement per inch control displacement in a given time), response (angular rate per inch control displacement) and sensitivity (angular acceleration per inch control displacement) characteristics were evaluated. Data were obtained by rapidly applying step control inputs of varying magnitude separately to the longitudinal, lateral and directional axes. These inputs were held until the maximum rate was reached or recovery was necessary.

Low Speed Flight Characteristics

25. Low speed flight characteristics were evaluated by flying the aircraft between 10 and 15 foot skid height at various azimuths in 5 knot increments up to V_T of 30 knots, if possible. When the inability to proceed to a higher airspeed or a limit airspeed was reached at a main rotor speed of 314 rpm, the condition was repeated at a rotor speed of 324 rpm for comparison. Tests were conducted in 5 knots of wind or less using a ground pace vehicle as a speed reference.

Accelerations and Decelerations

26. Constant altitude forward accelerations from an OGE hover to V_{NE} and back to hover and lateral accelerations from an OGE hover to V_T of 30 knots and back to a hover were conducted to evaluate associated maneuvering characteristics and main rotor flapping margins. The maneuver was initiated from a steady-state condition and consisted of increasingly rapid accelerations or decelerations to the new condition. Limit lateral airspeed was determined utilizing a calibrated ground pace vehicle.

Simulated Sudden Engine Failure

27. A loss of engine power was simulated by rapidly closing the twist grip throttle to the flight idle position. Following throttle reduction, the collective control was held fixed for increasing periods of time until two seconds was attained or recovery became necessary.

Hydraulic System Failure

28. A loss of hydraulic assist was simulated by turning the HYD BOOST switch to the OFF position.

Autorotational Landing

29. The autorotational landing characteristics were evaluated during straight approaches and during 180° turn approaches. Two techniques were utilized for the flare portion of the autorotation. Flares were initiated approximately 100 ft above ground level. One, the predetermined pitch attitude flare technique was initiated by an aft cyclic input to achieve

and maintain the predetermined pitch attitude to gain maximum deceleration effectiveness. The initial concern was in attaining the predetermined pitch attitude by reference to the attitude indicator. The deceleration was then evaluated through outside reference, and subsequently pertinent instruments were monitored inside the aircraft. Second, was a progressive flare as prescribed in the Aircrew Training Manual (ref 16, app A) initiated by a progressive increase in pitch attitude to produce a gradual increase in deceleration to gain maximum deceleration effectiveness. A continual cross check was maintained both outside the aircraft evaluating the deceleration as pitch attitude was progressively increased, and inside the aircraft monitoring pertinent instruments. Pitch rates for both techniques were similar.

VIBRATION

30. Spectral plots of each vibration parameter were generated depicting frequencies versus single amplitude acceleration (g), examples of which are shown in figures D-1 and D-2, appendix D for CMRB and STD, respectively. The data were analyzed using a frequency range of zero to 60 Hertz (Hz) and frequency resolution of 0.27 Hz. In order to minimize random variation in acceleration amplitude, the data were averaged over a 20-second time interval in level flight and a 5-second time interval in maneuvering flight. An analysis of the main rotor fundamental frequency and it's second, fourth, sixth and eighth harmonics was made. Complementary flight crew assessments were made using the Vibration Rating Scale (fig. D-3).

DEFINITIONS

31. Results were categorized as deficiencies or shortcomings in accordance with the following definitions.

Deficiency: A defect or malfunction discovered during the life cycle of an item of equipment that constitutes a safety hazard to personnel; will result in serious damage to the equipment if operation is continued; or indicates improper design or other cause of failure of an item or part, which seriously impairs the equipment's operational capability.

Shortcoming: An imperfection or malfunction occurring during the life cycle of equipment, which must be reported and which should be corrected to increase efficiency and render the equipment completely serviceable. It will not cause an immediate breakdown, jeopardize safe operation, or materially reduce the usability of the material or end product.

FIGURE D-1

COPTLOT SEAT VERTICAL VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRUE CALIBRATED AIRSPEED (KT)	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
7710	133.9	0.2RT	5430	25.5	318	102	LEVEL	CHRB/HUB SPRNG

NOTES:
1. MAIN ROTOR (M/R) 1/REV = 5.3 HERTZ
2. TAIL ROTOR (T/R) 1/REV = 27.2 HERTZ
3. FILTER CUT-OFF FREQUENCY = 80.0 HERTZ

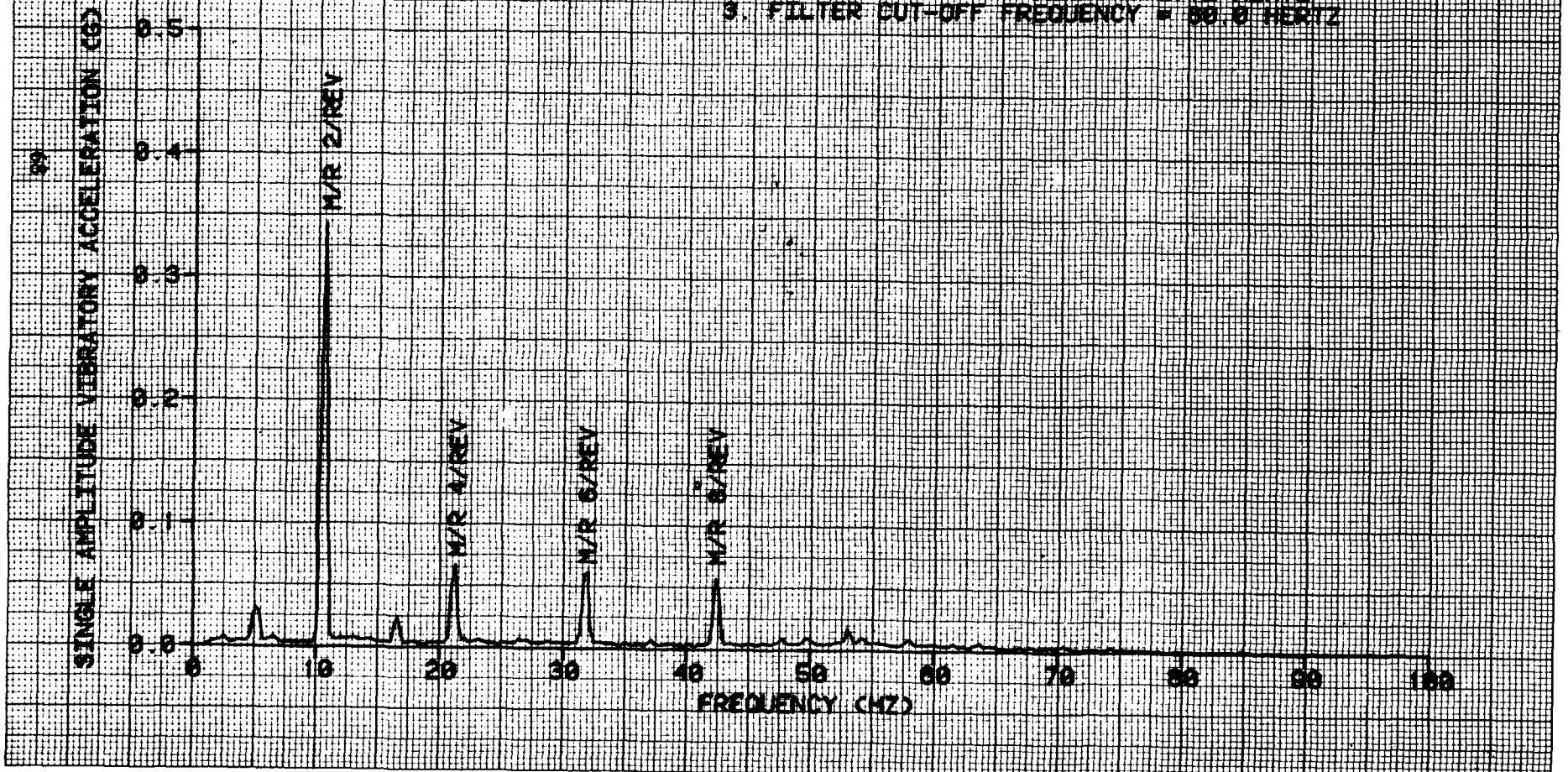


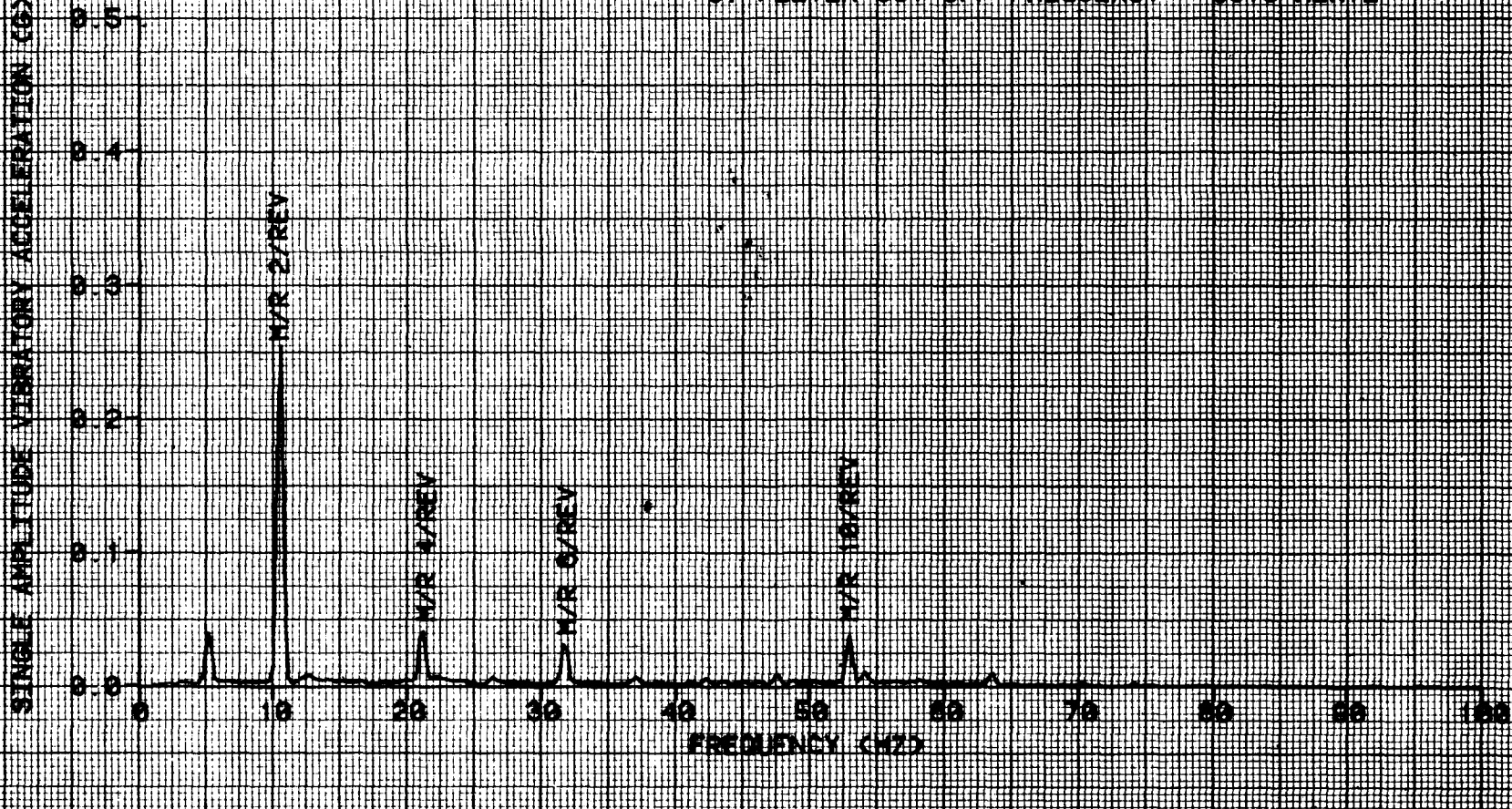
FIGURE D-2

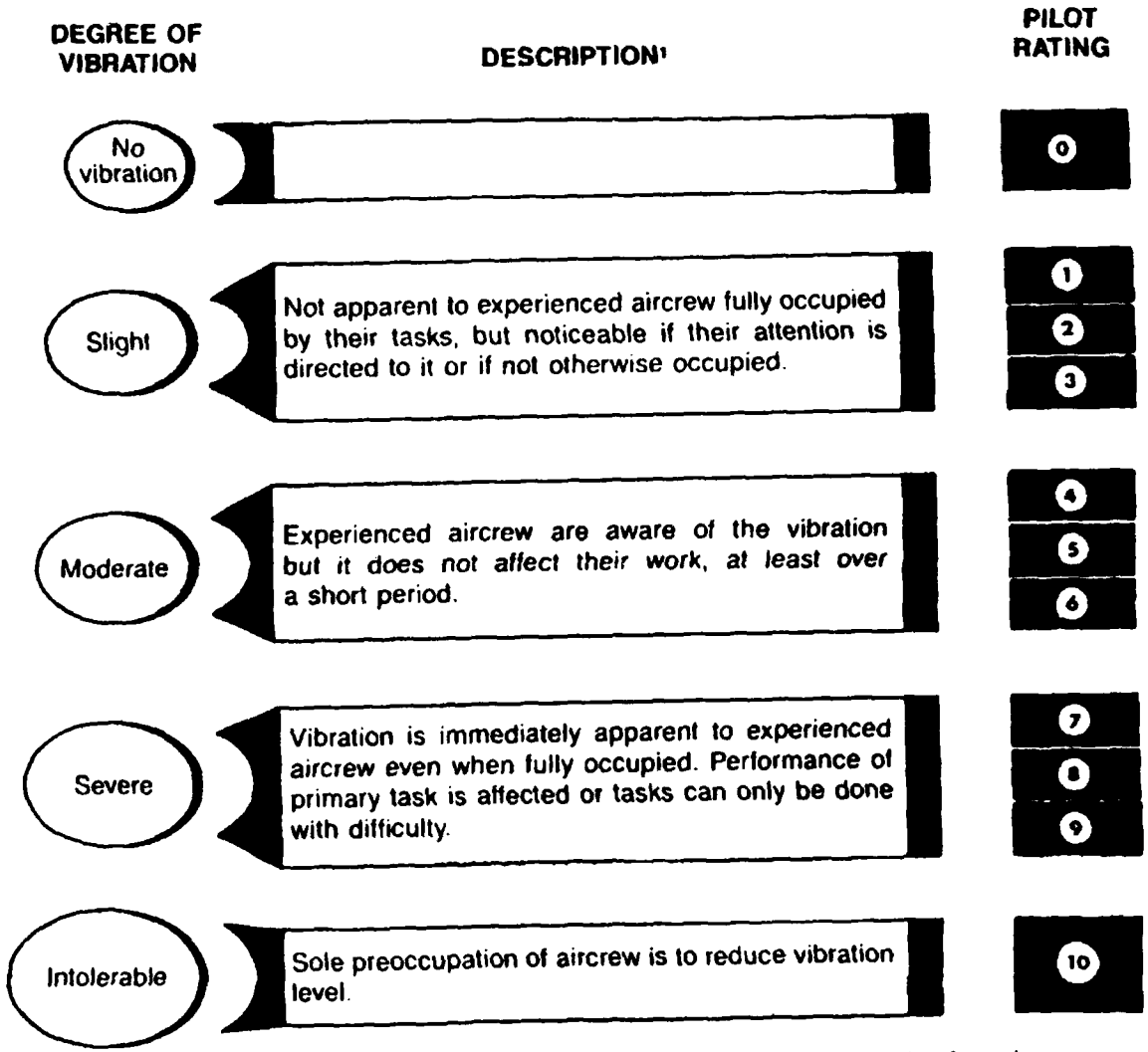
COPILOT SEAT VERTICAL VIBRATION CHARACTERISTICS

UH-1H USA S/N 66-16356

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
7820	132.8	0.0	7920	5.5	317	103	LEVEL	STD/HUB SPRING

NOTES: 1. MAIN ROTOR (M/R) 1/REV = 5.3 HERTZ
2. TAIL ROTOR (T/R) 1/REV = 27.0 HERTZ
3. FILTER CUT-OFF FREQUENCY = 80.0 HERTZ





[1]Based on the Subjective Vibration Assessment Scale developed by the Aeroplane and Armament Experimental Establishment, Boscombe Down, England.

Figure D-3. Vibration Rating Scale

APPENDIX E. TEST DATA

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Maneuvering Stability/Envelope	E-47 through E-56
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FIGURE 5-4

SUMMARY OVER CAPACITY

UH-1H USA SN 66-0953

MAIN ROTOR SPEED = 324 RPM

NOTES:

1. PROD CYRB/HUB SPRING CONFIGURATION
2. WINDS LESS THAN 3 KNOTS
3. HOVER DATA DERIVED FROM FIGURES 4 AND 5
4. MILITARY K30 MINUTE LIMITED POWER AVAILABLE OBTAINED FROM USAMEFA REPORT NO. 61-61-5 UTILIZING T53-L-13B ENGINE DECK 19.28.25.63

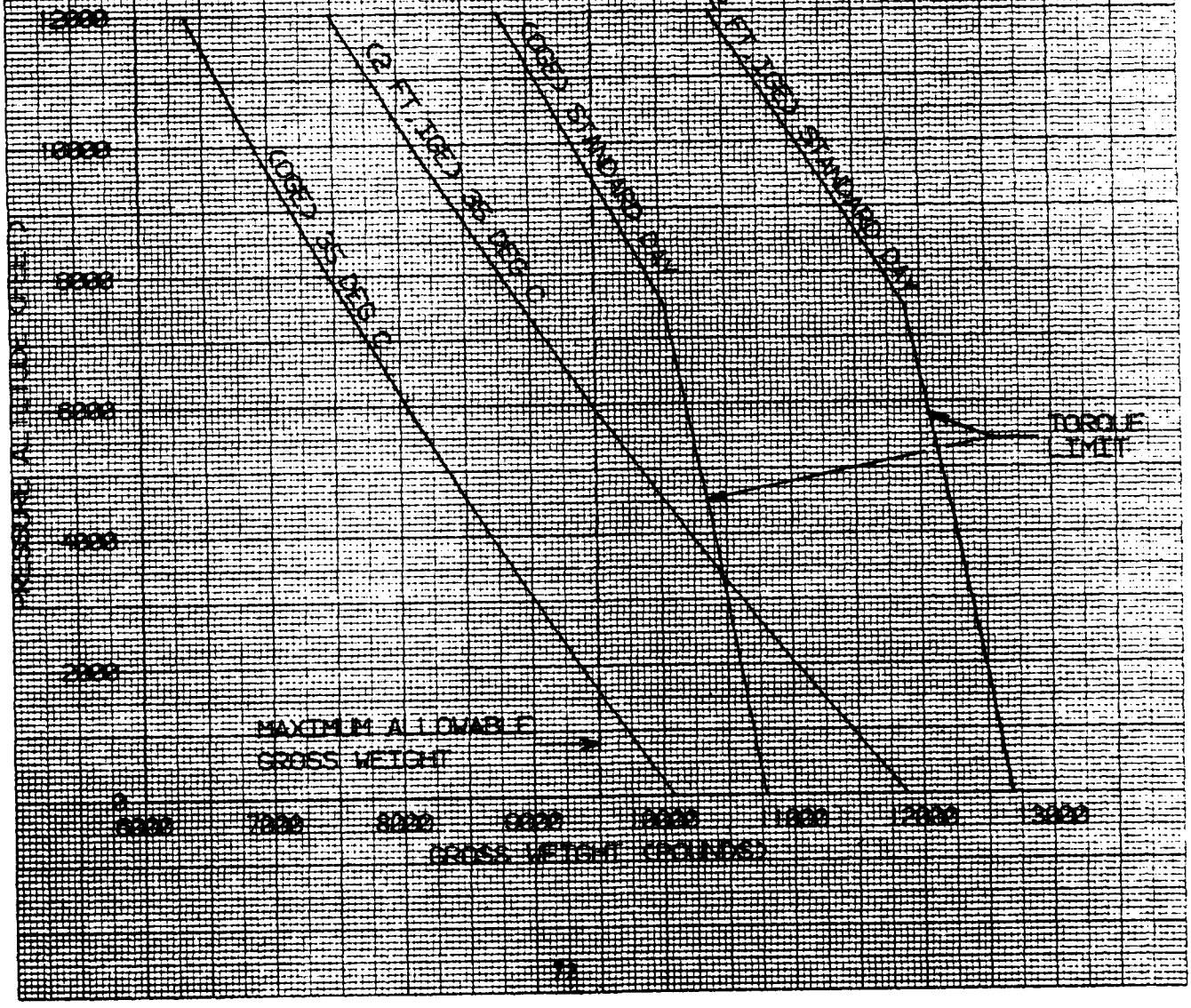


FIGURE E-2

NONDIMENSIONAL HOVER PERFORMANCE

UH-1H USA S/N 68-16358

PROD CMRB/HUB SPRING CONFIGURATION

NOTES:
1. TESTS CONDUCTED WITH AIRCRAFT TETHERED TO THE GROUND
2. WINDS LESS THAN 3 KNOTS
3. DISTANCE FROM BOTTOM OF SKIDS TO CENTER OF MAIN ROTOR HUB = 13.4 FT
4. CURVES BASED ON DATA FROM FIGURES 3 THROUGH 5

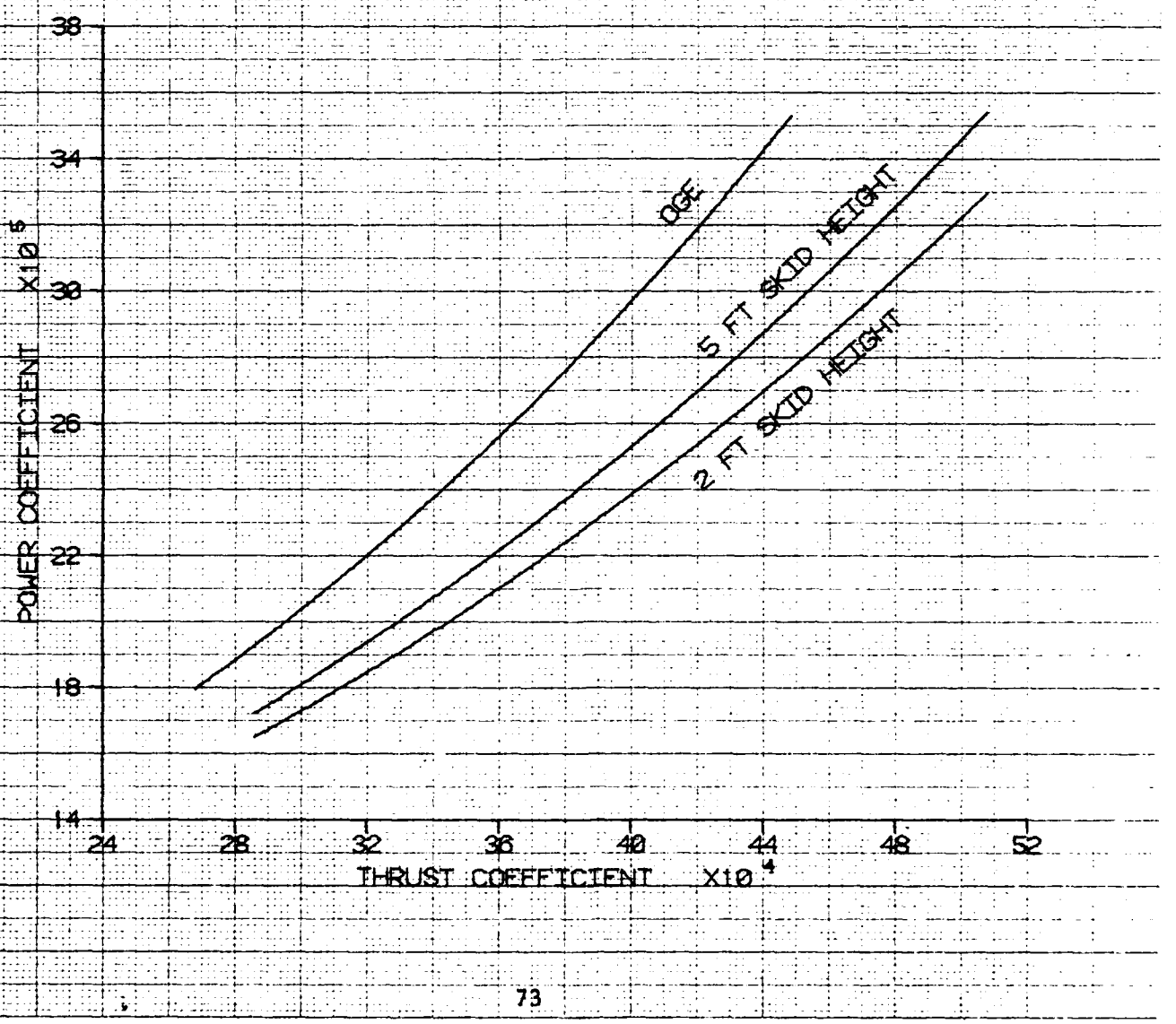


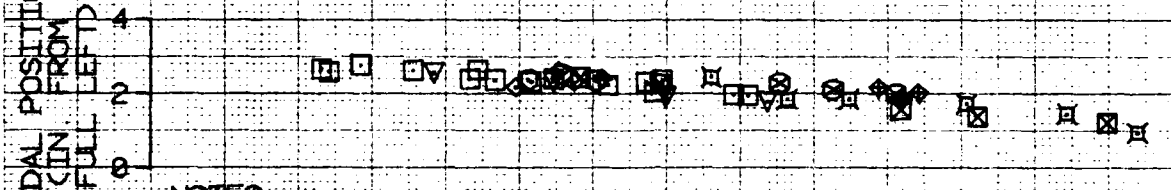
FIGURE E-3

NONDIMENSIONAL HOVER PERFORMANCE

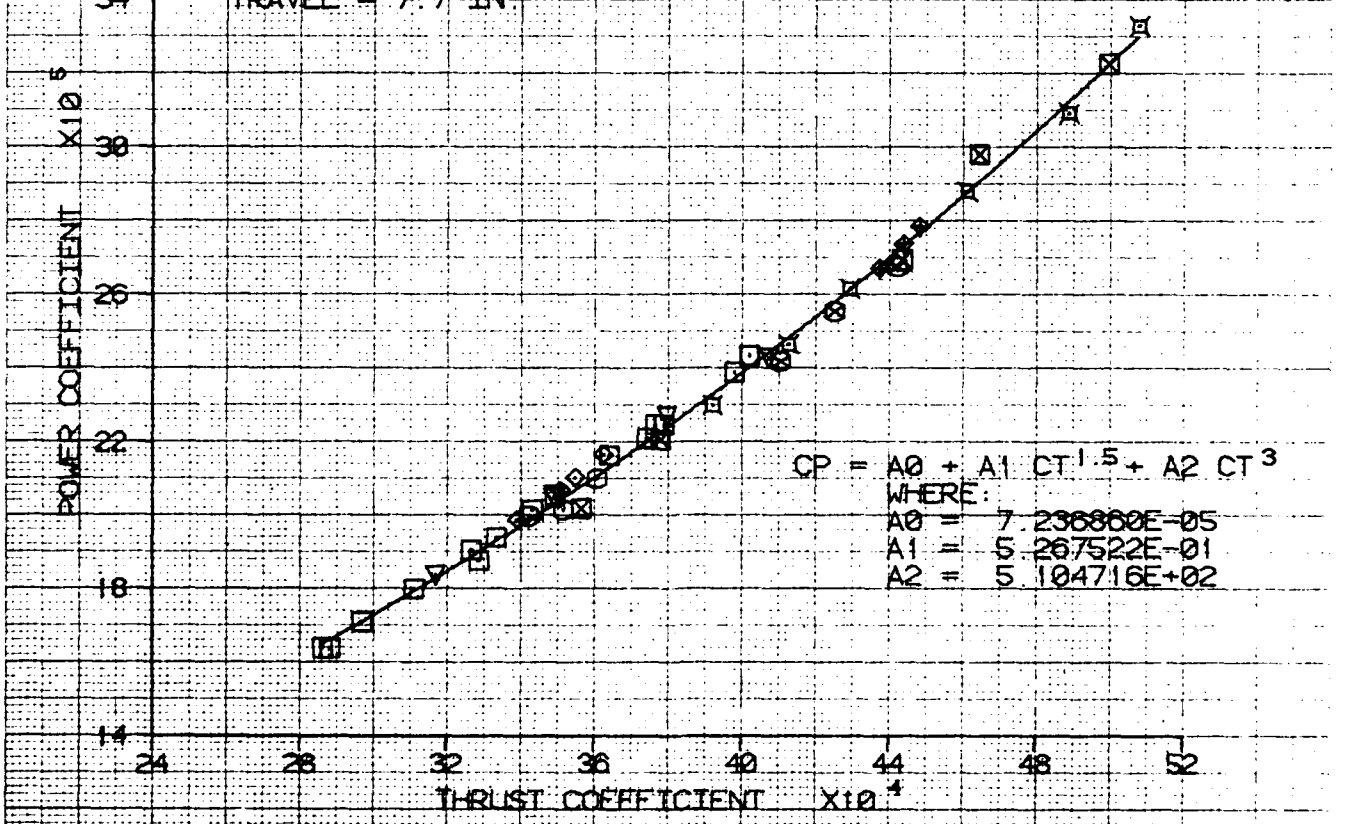
UH-1H USA S/N 68-16358

SKID HEIGHT = 2 FT

SYMBOL	DENSITY ALTITUDE (FT)	OAT (DEG C)	ROTOR SPEED (RPM)	REFERRED ROTOR SPEED (RPM)
⊕	11040	7.0	304	308
⊠	11000	7.0	324	329
◆	10900	6.5	294	299
⊞	10680	5.5	314	320
⊙	4500	31.0	303	295
◈	4200	29.0	294	287
⊡	4120	28.0	324	317
▽	3160	20.5	314	311



NOTES:
1. PROD CMRB/HUB SPRNG AND CMRB/HUB SPRNG CONFIGURATIONS
2. TESTS CONDUCTED WITH AIRCRAFT TETHERED TO THE GROUND
3. WINDS LESS THAN 3 KNOTS
4. DISTANCE FROM BOTTOM OF SKIDS TO CENTER OF MAIN ROTOR HUB = 13.4 FT
5. TOTAL DIRECTIONAL CONTROL TRAVEL = 7.7 IN



$$CP = A0 + A1\ CT^{1.5} + A2\ CT^{3}$$

WHERE:
A0 = 7.236860E-05
A1 = 5.267522E-01
A2 = 5.104716E+02

FIGURE E-4

NONDIMENSIONAL HOVER PERFORMANCE

UH-1H USA S/N 68-16358

SKID HEIGHT = 5 FT

SYMBOL	DENSITY ALTITUDE (FT)	OAT (DEG C)	ROTOR SPEED (RPM)	REFERRED ROTOR SPEED (RPM)
⊠	10900	6.5	313	318
▽	3480	22.5	314	310
○	3400	22.0	304	300
◇	3400	22.0	295	291
□	3240	21.0	324	321

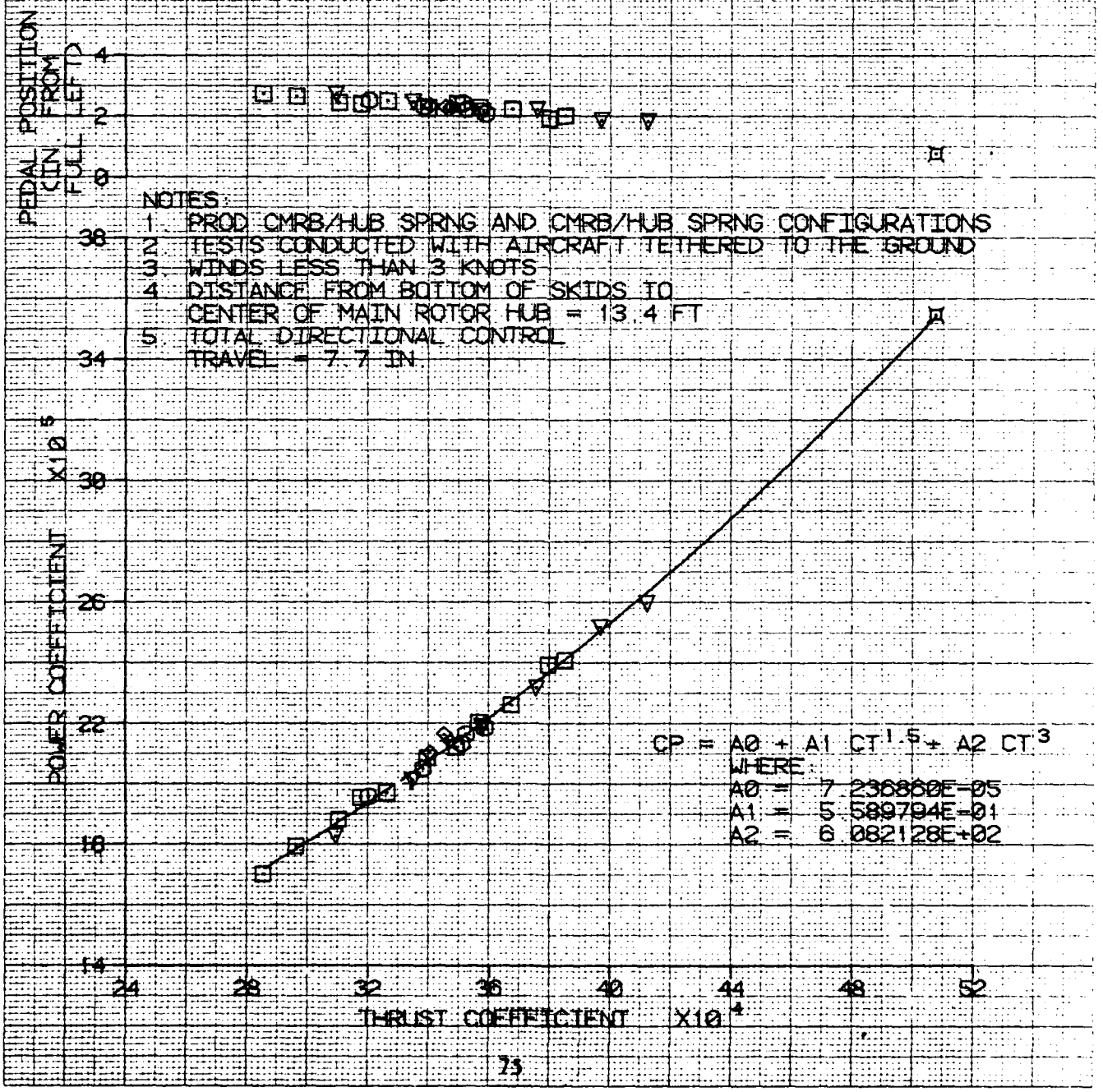


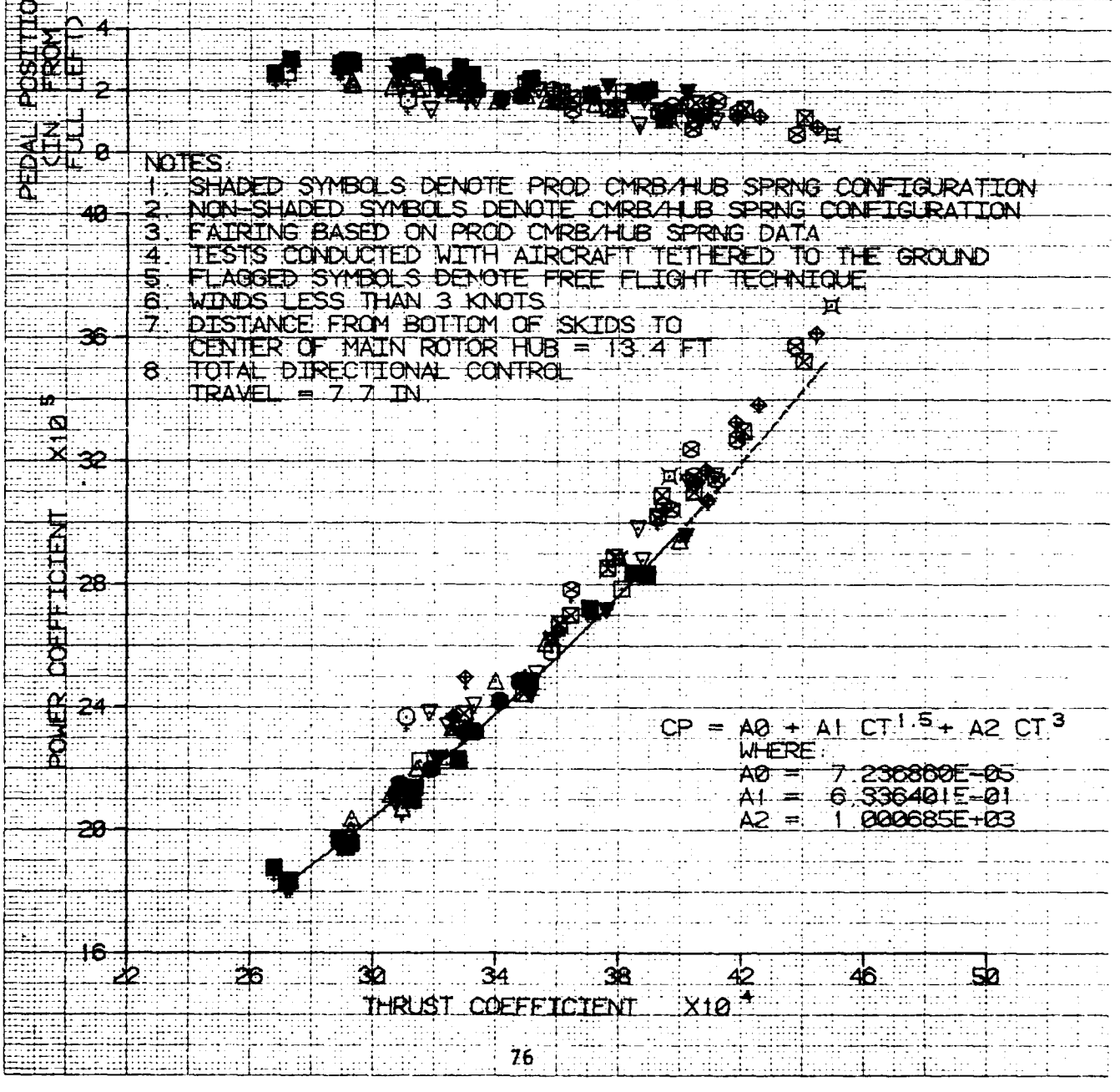
FIGURE E-5

NONDIMENSIONAL HOVER PERFORMANCE

UH-1H USA S/N 68-16358

SKID HEIGHT = 60 FT (OGE)

SYMBOL	DENSITY ALTITUDE (FT)	OAT (DEG C)	ROTOR SPEED (RPM)	REFERRED ROTOR SPEED (RPM)
⌘	10390	-0.5	313	322
⊗	10380	-0.5	304	312
⊠	10340	-1.0	324	333
◆	9380	2.5	294	301
△	4100	26.5	319	312
⊡, ■	3500	22.5	324	320
◈, ◆	3460	22.5	294	290
▽, ▼	3420	20.5	314	311
⊙, ●	3360	21.0	304	301



NOTES:

1. SHADED SYMBOLS DENOTE PROD CMRB/HUB SPRNG CONFIGURATION
2. NON-SHADED SYMBOLS DENOTE CMRB/HUB SPRNG CONFIGURATION
3. FAIRING BASED ON PROD CMRB/HUB SPRNG DATA
4. TESTS CONDUCTED WITH AIRCRAFT TETHERED TO THE GROUND
5. FLAGGED SYMBOLS DENOTE FREE FLIGHT TECHNIQUE
6. WINDS LESS THAN 3 KNOTS
7. DISTANCE FROM BOTTOM OF SKIDS TO CENTER OF MAIN ROTOR HUB = 13.4 FT
8. TOTAL DIRECTIONAL CONTROL TRAVEL = 7.7 IN

$$CP = A0 + A1\ CT^{1.5} + A2\ CT^{3}$$

WHERE

A0 = 7.236860E-05
A1 = 6.336401E-01
A2 = 1.000685E+03

FIGURE E-6

NONDIMENSIONAL HOVER PERFORMANCE

UH-1H USA S/N 68-16358

SKID HEIGHT = 00 FT (OGE)

SYMBOL	DENSITY ALTITUDE (FT)	OAT (DEG C)	ROTOR SPEED (RPM)	REFERRED ROTOR SPEED (RPM)
◆	2780	16.5	294	294
○	2300	12.5	304	305
⊡	2340	13.0	323	324
▽	2180	11.5	312	314

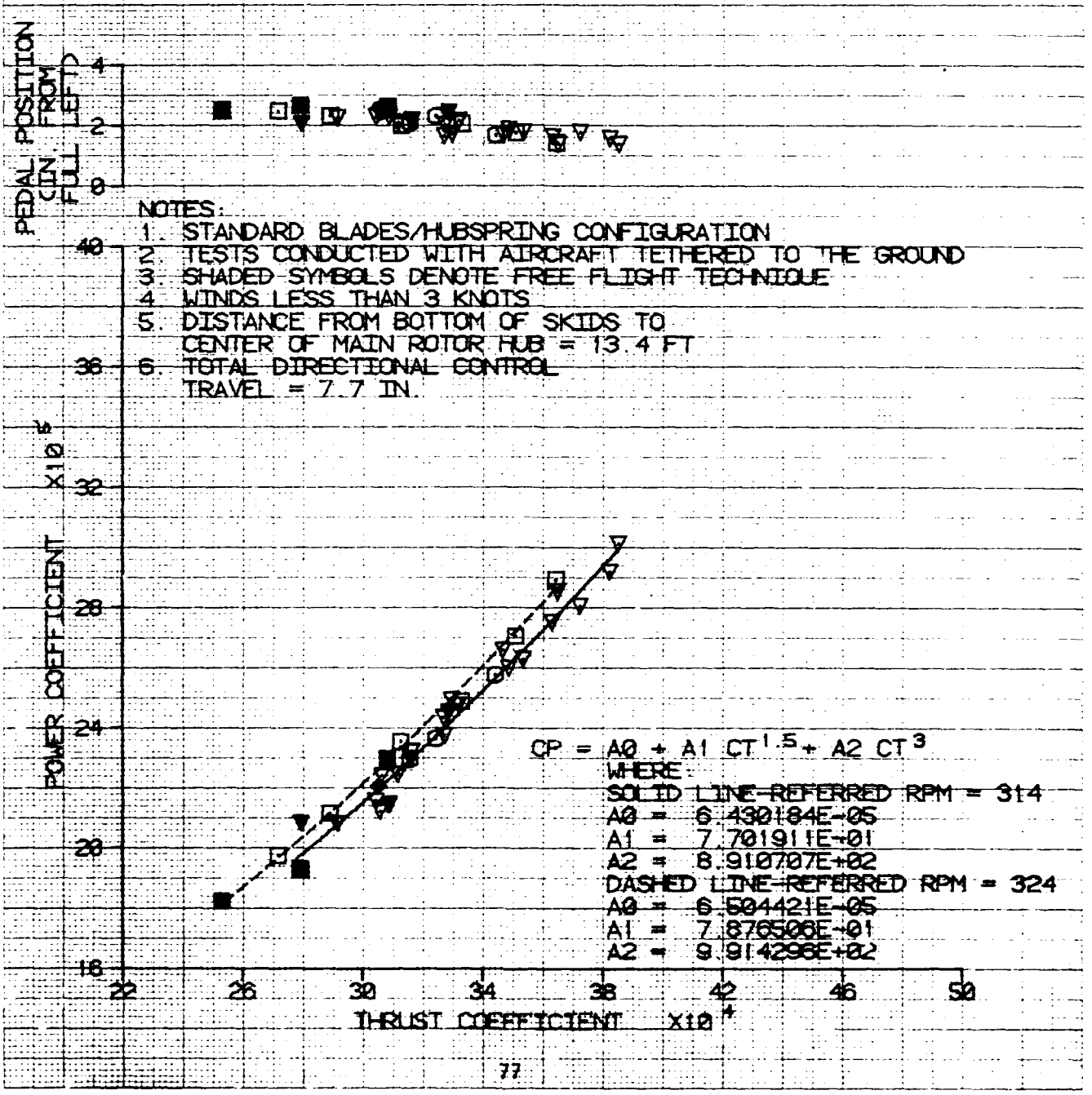


FIGURE E-7

VARIATION IN RATE OF CLIMB AS A FUNCTION OF SHAFT HORSEPOWER

UH-1H USA S/N 68-16358

SYM	DENSITY ALTITUDE (FT)	GROSS WEIGHT (LB)	AVG ROTOR SPEED (RPM)
⊡	10000	7700	324
⊙	10000	7700	314
⊠	5000	7700	324
⊗	5000	7700	313

NOTES: 1. PROD CMBR/HUB SPRNG CONFIGURATION
2. BEST RATE OF CLIMB AIRSPEED DETERMINED FROM FIGURES 10 THROUGH 13
3. LINE BASED ON AN AVERAGE Kp=0.83 WHERE,

$$K_p = \frac{\Delta R/C}{\Delta SHP} \times \frac{GW}{33000}$$

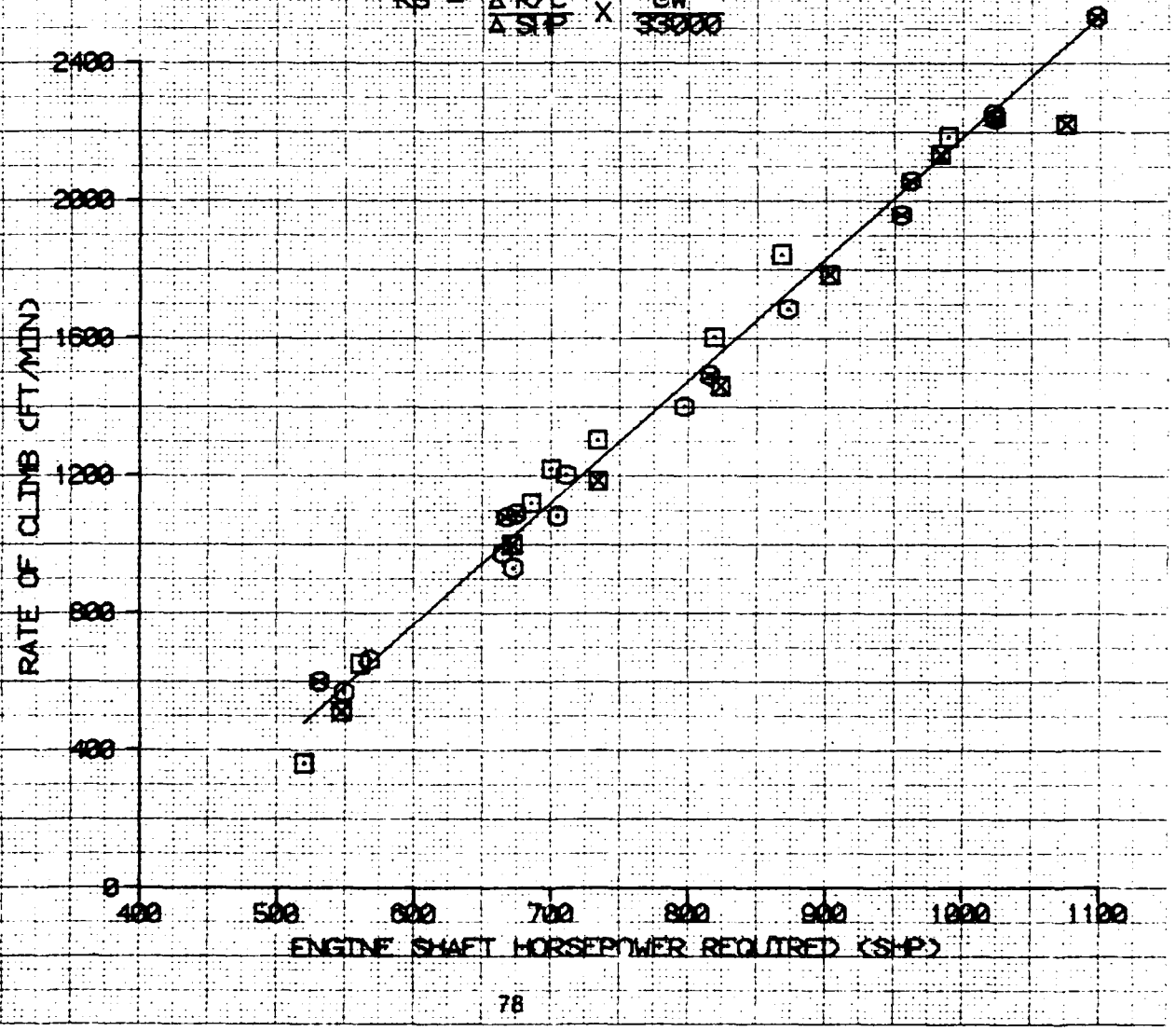


FIGURE E-8

NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE

UH-1H USA S/N 68-16358

REFERRED ROTOR SPEED = 303.7

NOTES:
1. PROD CMRB/HUB SPRNG AND CMRB/HUB SPRNG CONFIGURATIONS
2. ZERO DEGREE SIDESLIP TRIM CONDITION
3. AVG LONGITUDINAL C.G. LOCATION AT FS 132.9
4. MID LATERAL C.G. LOCATION
5. POINTS DERIVED FROM FIGURES 14 THRU 20

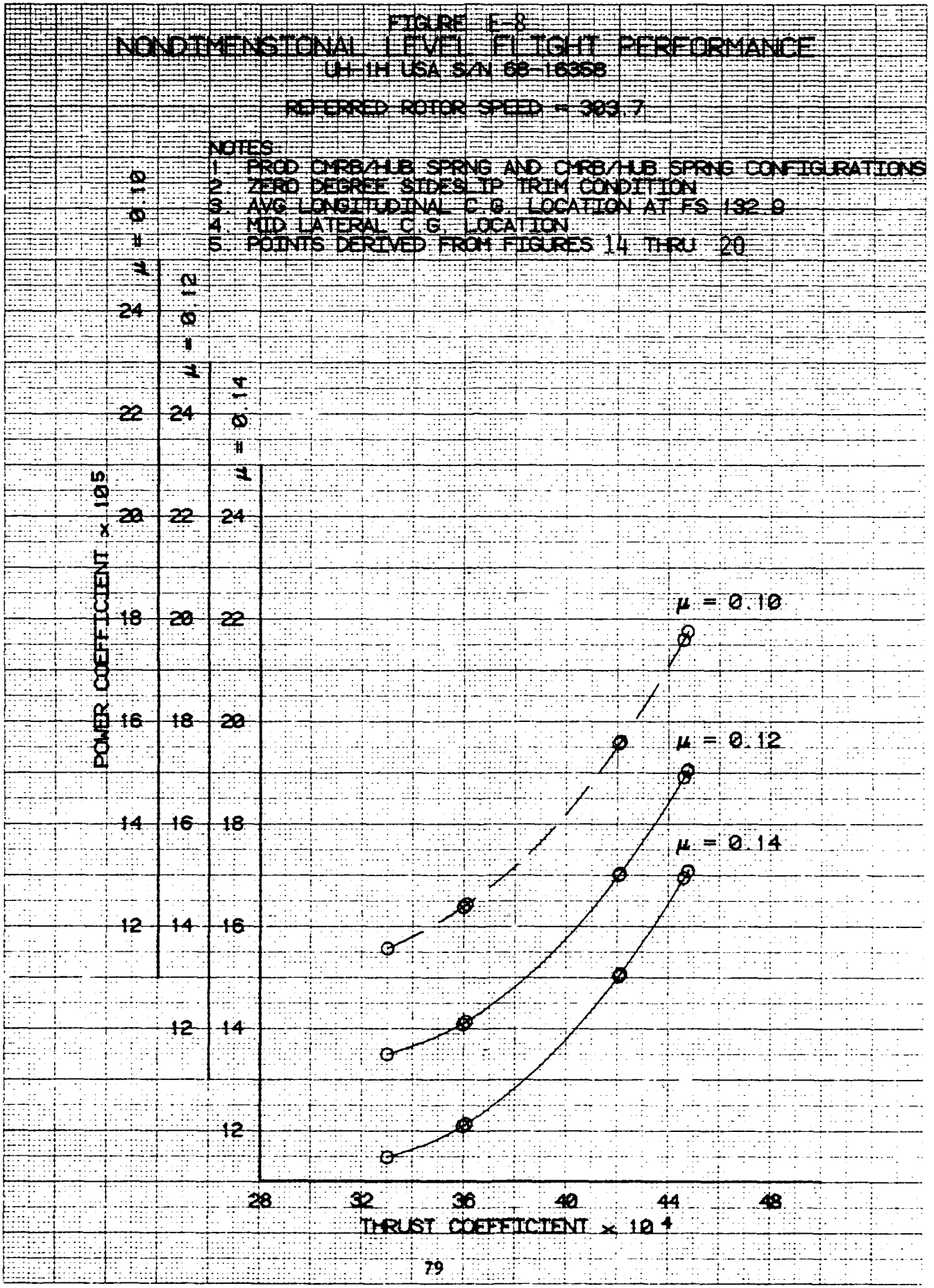


FIGURE E-9

NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE

UH-1H USA S/N 68-16368

REFERRED ROTOR SPEED = 323.7

NOTES:
1. PROD CMRB/HUB SPRNG AND CMRB/HUB SPRNG CONFIGURATIONS
2. ZERO DEGREE SIDESLIP TRIM CONDITION
3. AVG LONGITUDINAL C.G. LOCATION AT FS 132.9
4. MID LATERAL C.G. LOCATION
5. POINTS DERIVED FROM FIGURES 14 THRU 20

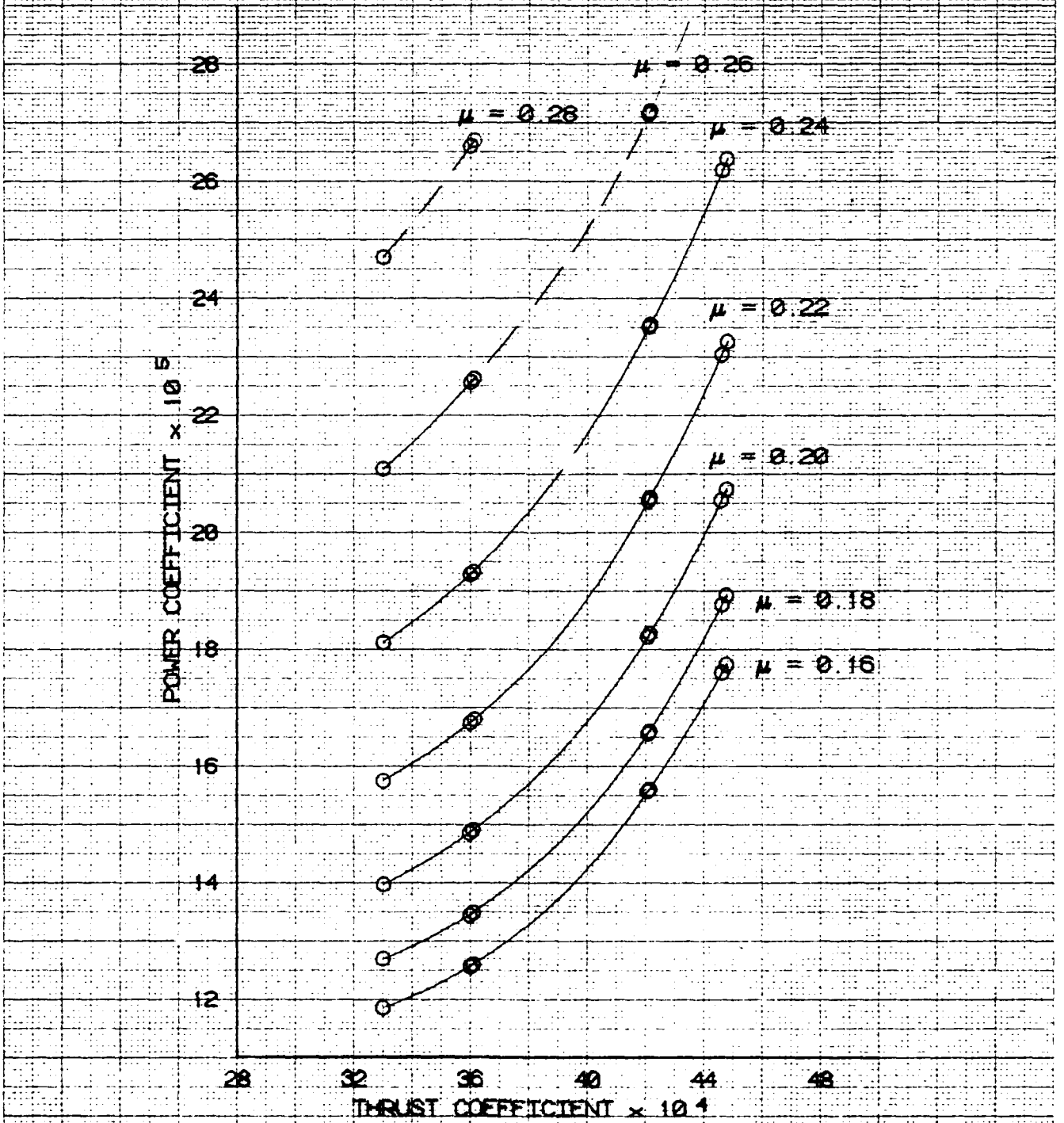


FIGURE E-10

NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE

UH-1H USA S/N 68-16358

REFERRED ROTOR SPEED = 313.7

NOTES:
1. PROD CMRB/HUB SPRNG AND CMRB/HUB SPRNG CONFIGURATIONS
2. ZERO DEGREE SIDESLIP TRIM CONDITION
3. AVG LONGITUDINAL C.G. LOCATION AT FS 133.0
4. MID LATERAL C.G. LOCATION
5. POINTS DERIVED FROM FIGURES 21 THRU 27

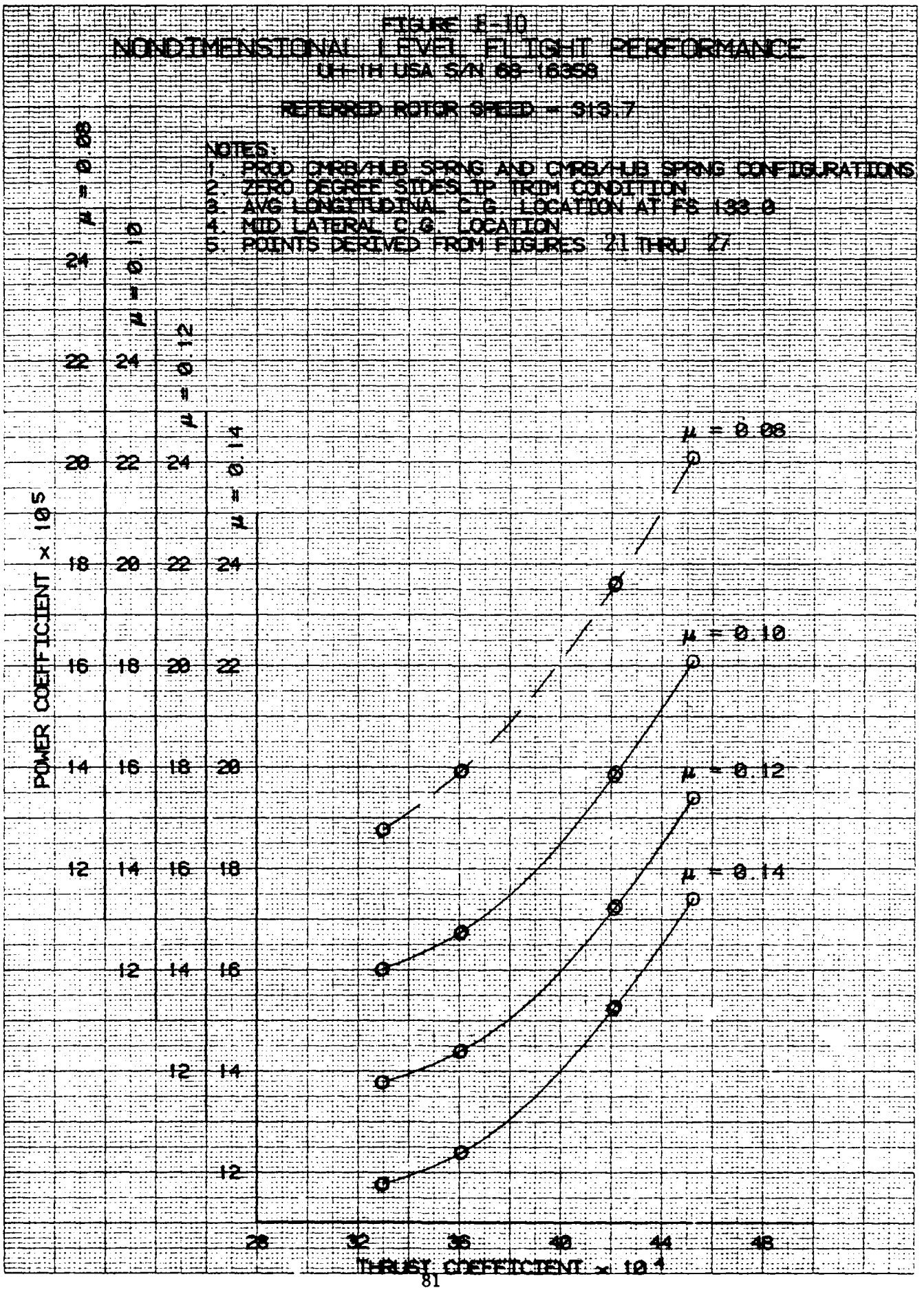


FIGURE E-11

NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE

UH-1H USA S/N 68-16358

REFERRED ROTOR SPEED = 313.7

NOTES:
1. PROD CMRB/HUB SPRNG AND CMRB/HUB SPRNG CONFIGURATIONS
2. ZERO DEGREE SIDESLIP TRIM CONDITION
3. AVG LONGITUDINAL C.G. LOCATION AT FS 133.0
4. MID LATERAL C.G. LOCATION
5. POINTS DERIVED FROM FIGURES 21 THRU 27

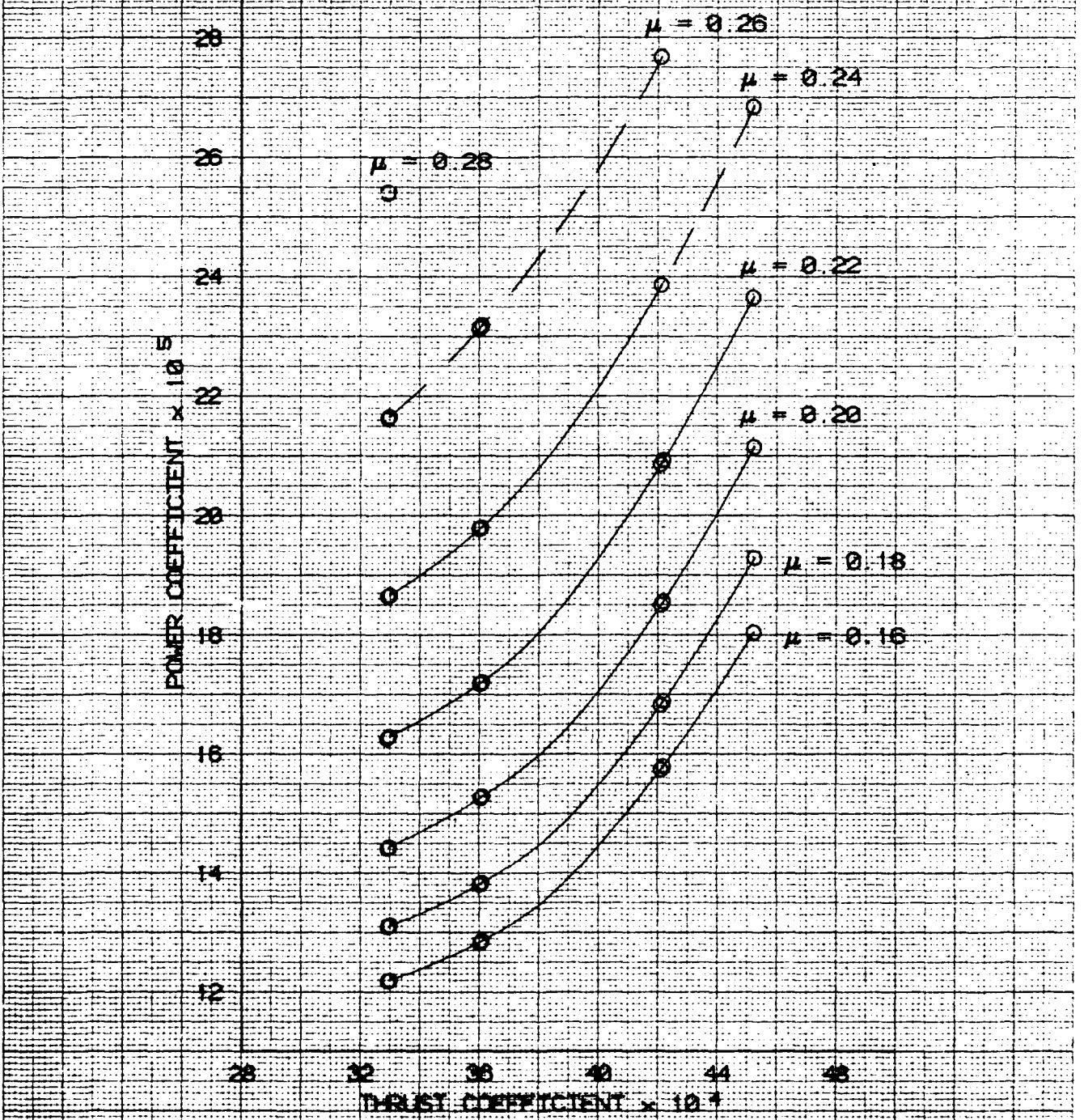


FIGURE E-12

NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE

UH-1H USA S/N 68-16358

REFERRED ROTOR SPEED = 323.6

NOTES:
1. PROD CHRB/HUB SPRNG CONFIGURATION
2. ZERO DEGREE SIDESLIP TRIM CONDITION
3. AVG LONGITUDINAL C.G. LOCATION AT FS 132.9
4. MID LATERAL C.G. LOCATION
5. POINTS DERIVED FROM FIGURES 28 THRU 31

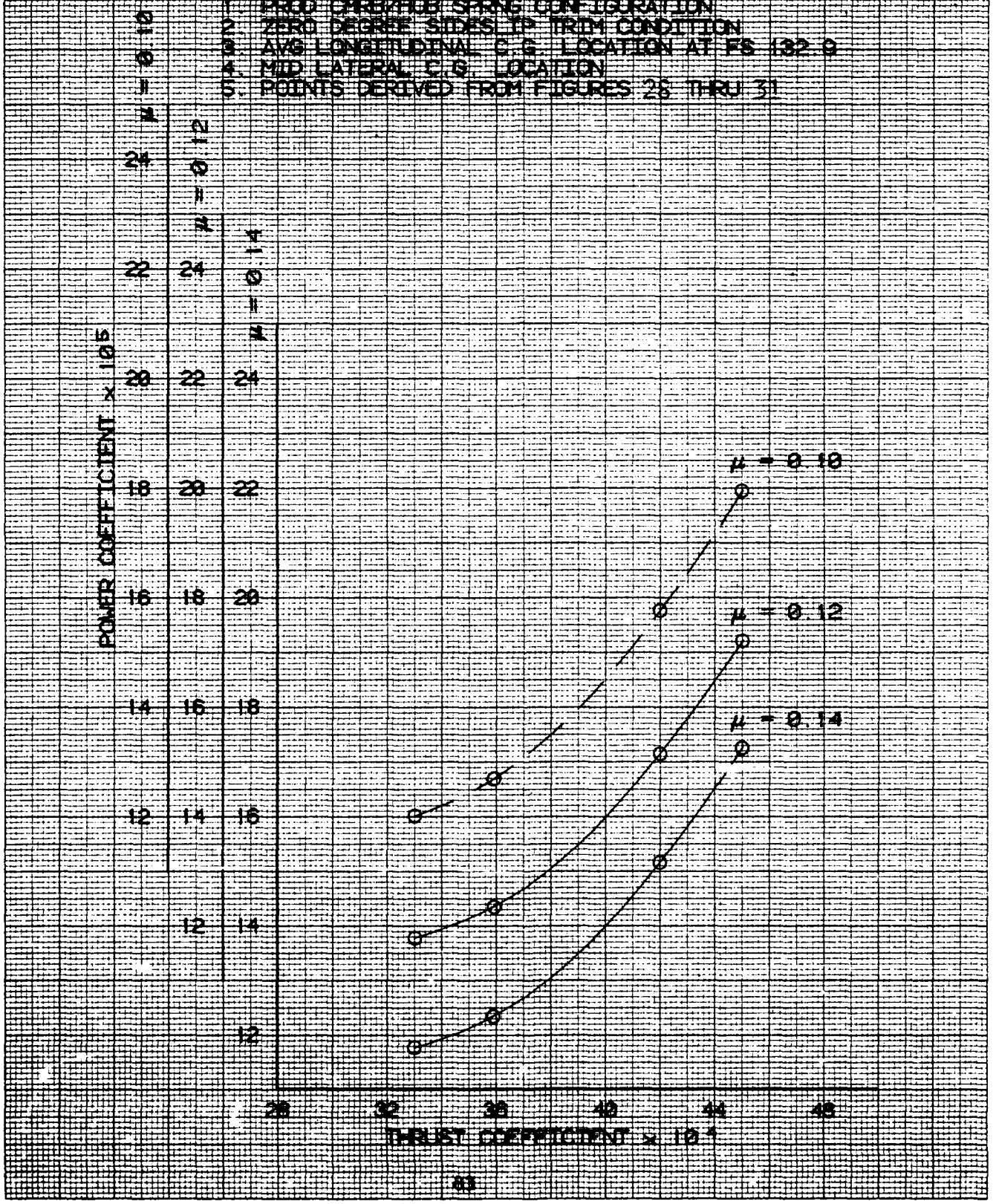


FIGURE E-13

NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE

UH-1H USA S/N 68-16358

REFERRED ROTOR SPEED = 323.0

NOTES:
1. PROD CHRB/HUB SPRING CONFIGURATION
2. ZERO DEGREE SIDESLIP TRIM CONDITION
3. AVG LONGITUDINAL C.G. LOCATION AT FS 132.9
4. MID LATERAL C.G. LOCATION
5. POINTS DERIVED FROM FIGURES 28 THRU 31

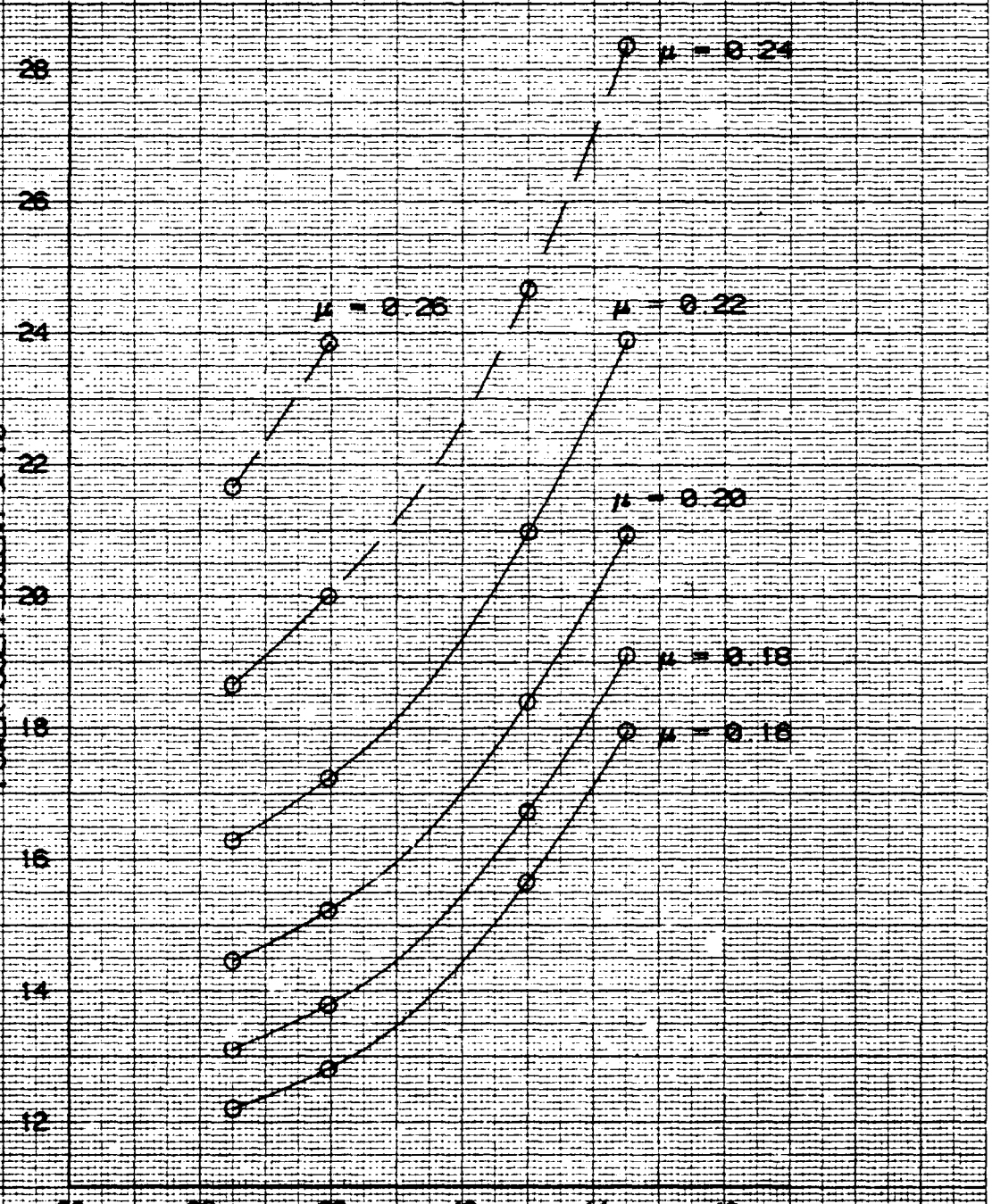


FIGURE E-14

LEVEL FLIGHT PERFORMANCE
UH-1H USA S/N 66-16558

AVG GROSS WEIGHT (LBS)	AVG C.G. LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALTITUDE (FEET)	AVG O.A.T. (DEG C)	AVG REF ROTOR SPEED (RPM)	AVG C_T	CONFIGURATION
7200	132.8(FWD)	0.1LT	5040	18.5	303.5	0.003303	PROD CMRB/ HUB SPRNG

NOTE: ZERO DEGREE SIDESLIP

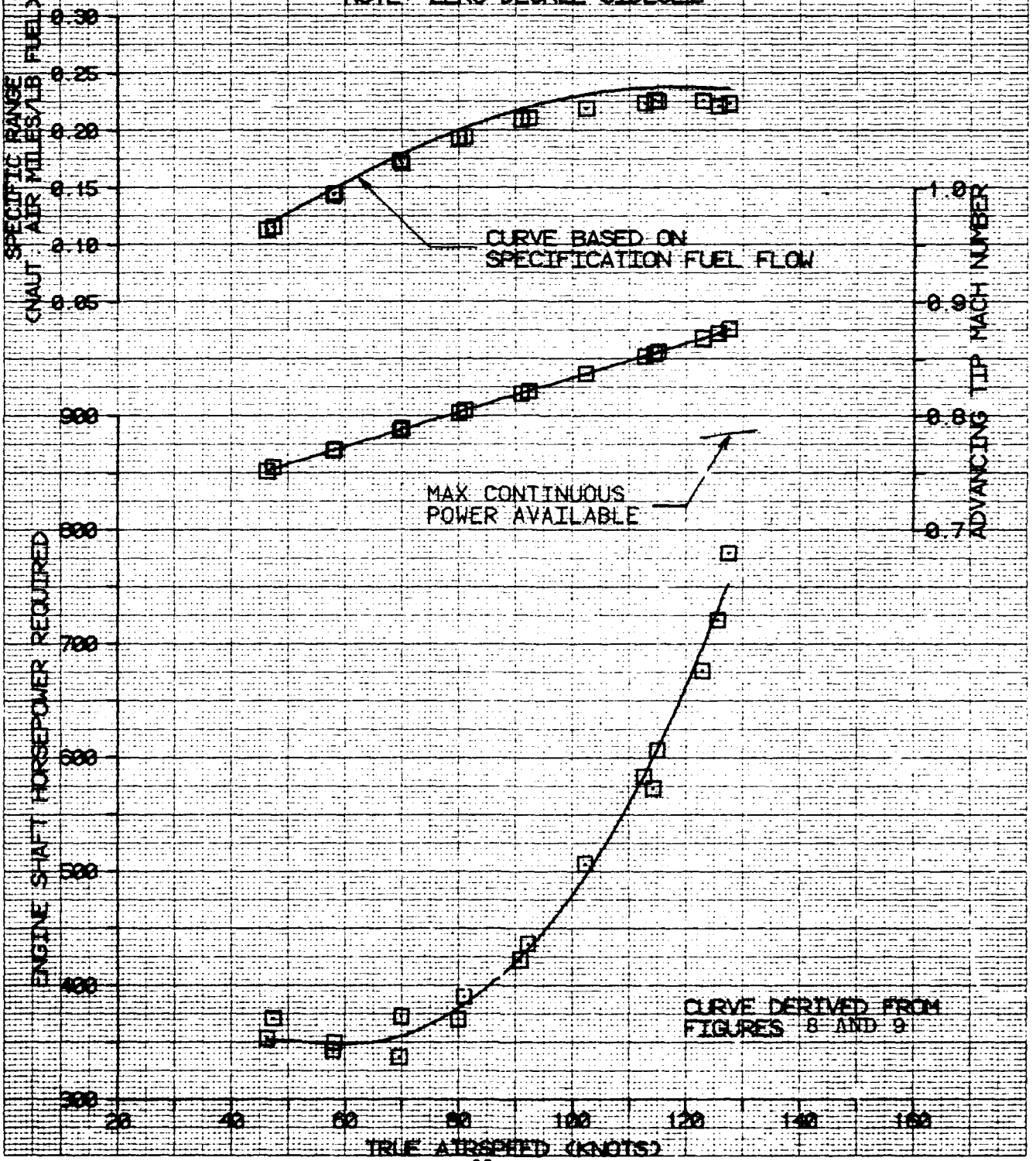


FIGURE C-15
LEVEL FLIGHT PERFORMANCE
UH-1H USA S/N 66-16555

AVG GROSS WEIGHT (LBS)	C.G. LOCATION LONG (FSS)	LAT (BL)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (DEG C)	AVG REF ROTOR SPEED (RPM)	AVG C_T	CONFIGURATION
7770	133.3 (FWD)	0 LT	5110	16.0	303.6	0.003600	PROD CHRB/ HUB SPRNG

NOTE: ZERO DEGREE SIDESLIP

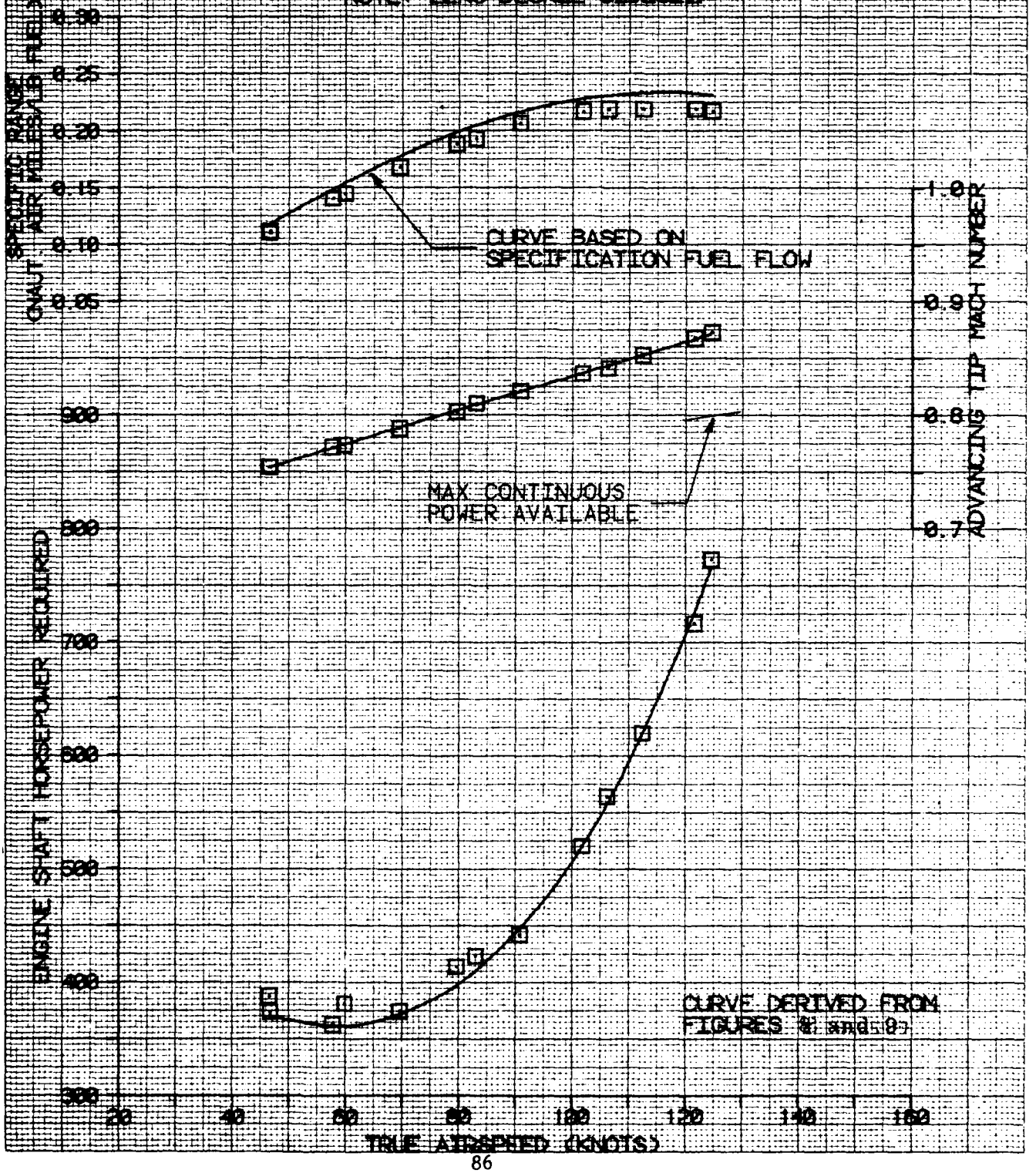


FIGURE E-1.k_c
LEVEL FLIGHT PERFORMANCE
OH-1H USA S/N 68-15558

AVG GROSS WEIGHT (LBS)	C.G. LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (DEG C)	AVG REF ROTOR SPEED (RPM)	AVG C_T	CONFIGURATION
7000	133.3(FWD)	0	9850	18.0	383.5	0.004211	2600 CHRG/ 4.5 SPIKE

NOTE: ZERO DEGREE SIDESLIP

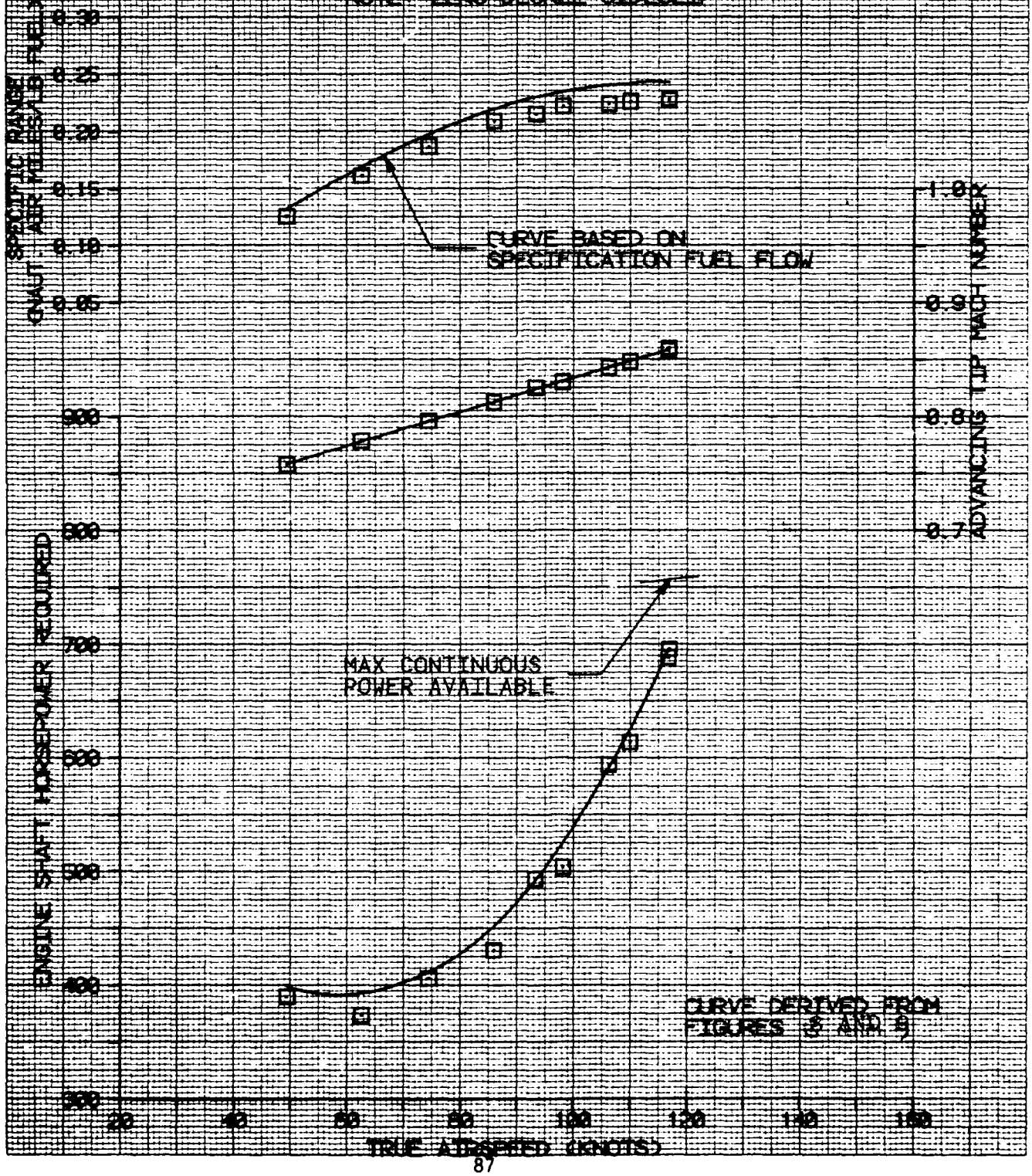


FIGURE 8-17
LEVEL FLIGHT PERFORMANCE
CH-47A USA S/N 66-19000

AVG GROSS WEIGHT (LBS)	AVG C.G. LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (DEG C)	AVG REF ROTOR SPEED (RPM)	AVG C_T	CONFIGURATION
7850	132.7(FWD)	0	10270	25	304.1	0.004481	PROD CYRRL/ HUB SPRNG

NOTE: ZERO DEGREE SIDESLIP

SPECIFIC RANGE (NAUT AIR MILES/LB FUEL)

ENGINE SHAFT HORSEPOWER REQUIRED

ADVANCING TIP MACH NUMBER

CURVE BASED ON SPECIFICATION FUEL FLOW

MAX CONTINUOUS POWER AVAILABLE

CURVE DERIVED FROM FIGURES 8 AND 9

TRUE AIRSPEED (KNOTS)

FIGURE 12-18

LEVEL FLIGHT PERFORMANCE
UH-1H USA S/N 66-16558

AVG GROSS WEIGHT (LB)	C.G. LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALTITUDE (FEET)	AVG O.A.T. (DEG C)	AVG REF ROTOR SPEED (RPM)	AVG C_T	CONFIGURATION
7760	132.9 (FWD)	0	6050	23.0	323.6	0.0036513	CHRB/ HUB SPRNG

NOTE: ZERO DEGREE SIDESLIP

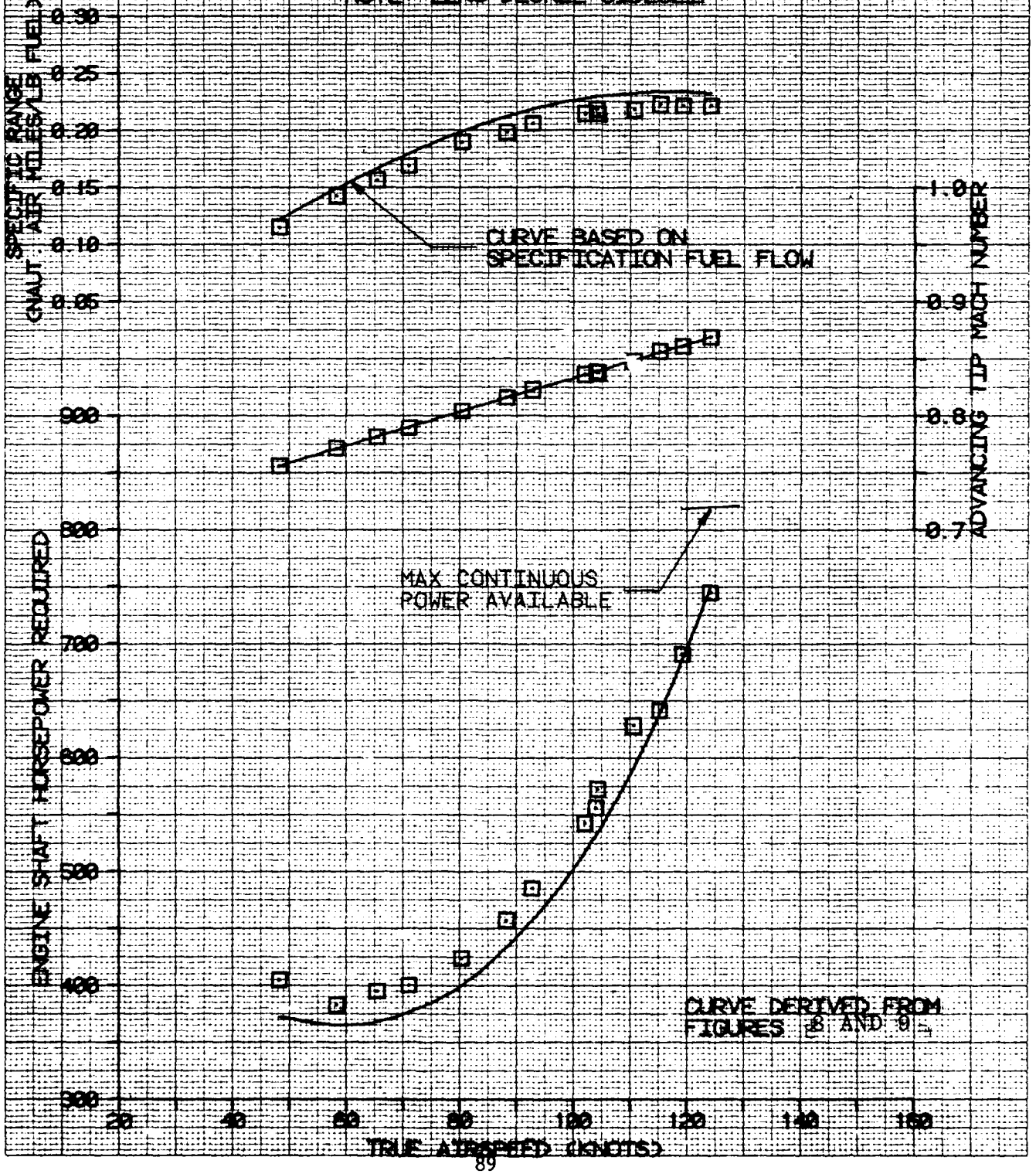


FIGURE E-19:
LEVEL FLIGHT PERFORMANCE
UH-1N USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG C.G. LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALTITUDE (FEET)	AVG O.A.T. (DEG C)	AVG REF. ROTOR SPEED (RPM)	AVG C_T	CONFIGURATION
7670	132.2(FWD)	0.2RT	10400	13.5	303.9	0.004214	CMRB/ HUB SPRNG

NOTE: ZERO DEGREE SIDESLIP

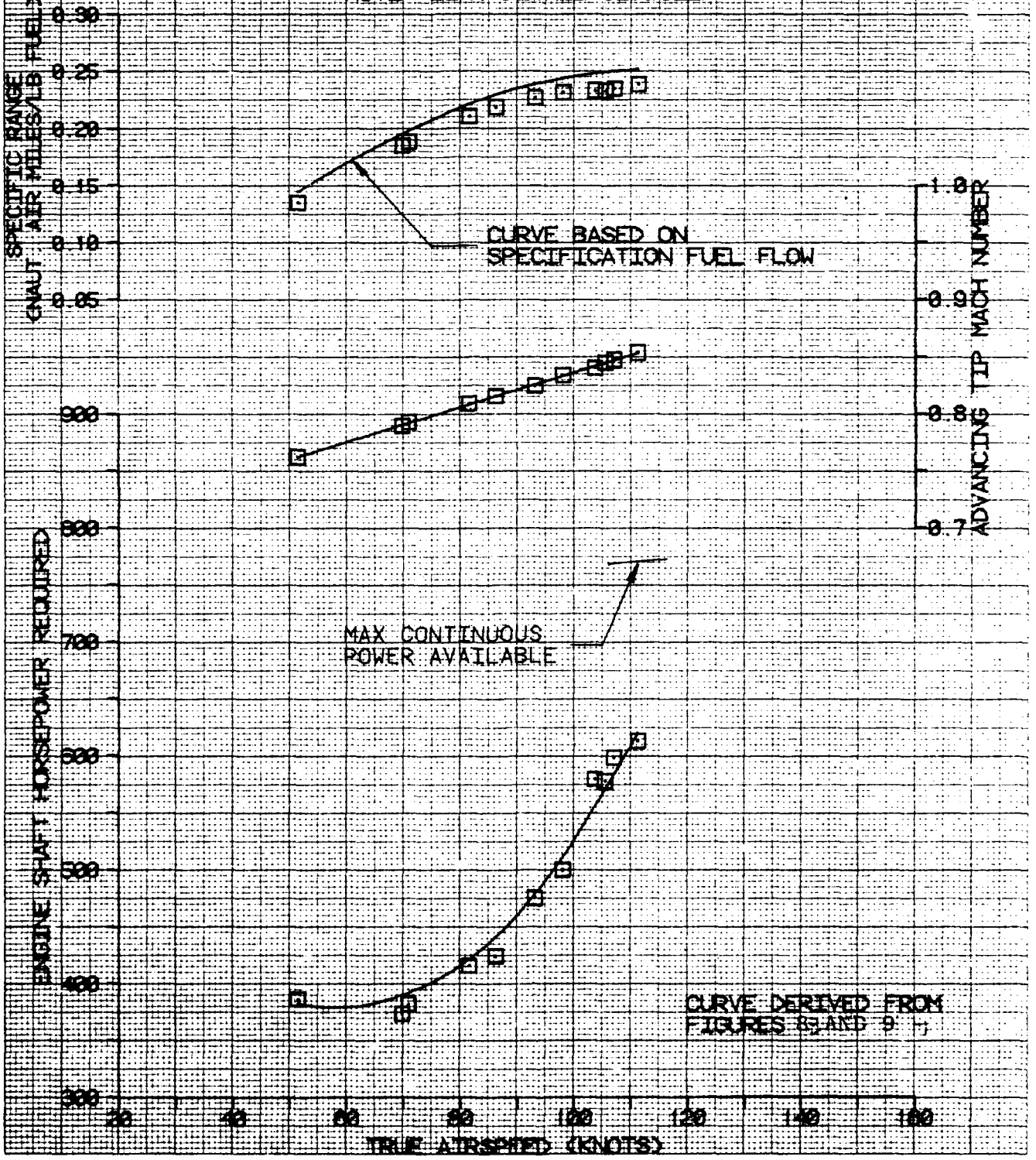


FIGURE 9a(2)-C

LEVEL FLIGHT PERFORMANCE

UH-1H USA S/N 66-16558

AVG GROSS WEIGHT (LBS)	C.G. LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	AVG C_T	CONFIGURATION
7700	192.7(FWD)	0 ILT	12150	18.5	383.7	0.004478	CH46/ HUB SPRND

NOTE: ZERO DEGREE SIDESLIP

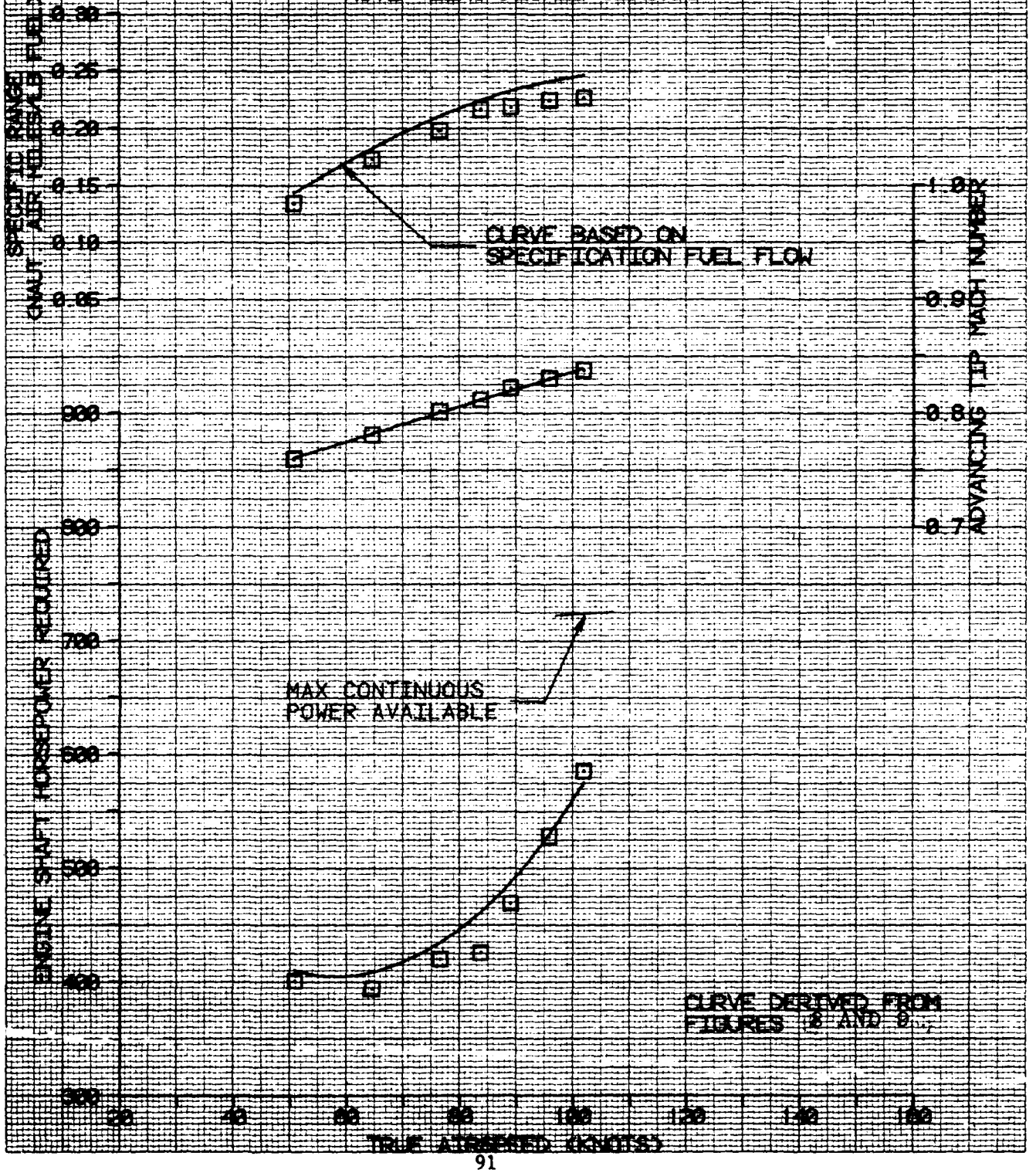


FIGURE 3-2-1.A

LEVEL FLIGHT PERFORMANCE

UH-1H USA S/N 66-16536

AVG GROSS WEIGHT (LBS)	C.G. LONG (FS)	AVG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FEET)	AVG O A T (DEG C)	AVG REF ROTOR SPEED (RPM)	AVG C_T	CONFIGURATION
7720	133.1(FWD)	0.0	4750	17.0	313.8	0.003301	PROG CHRB/ HUB SPRND

NOTE: ZERO DEGREE SIDESLIP

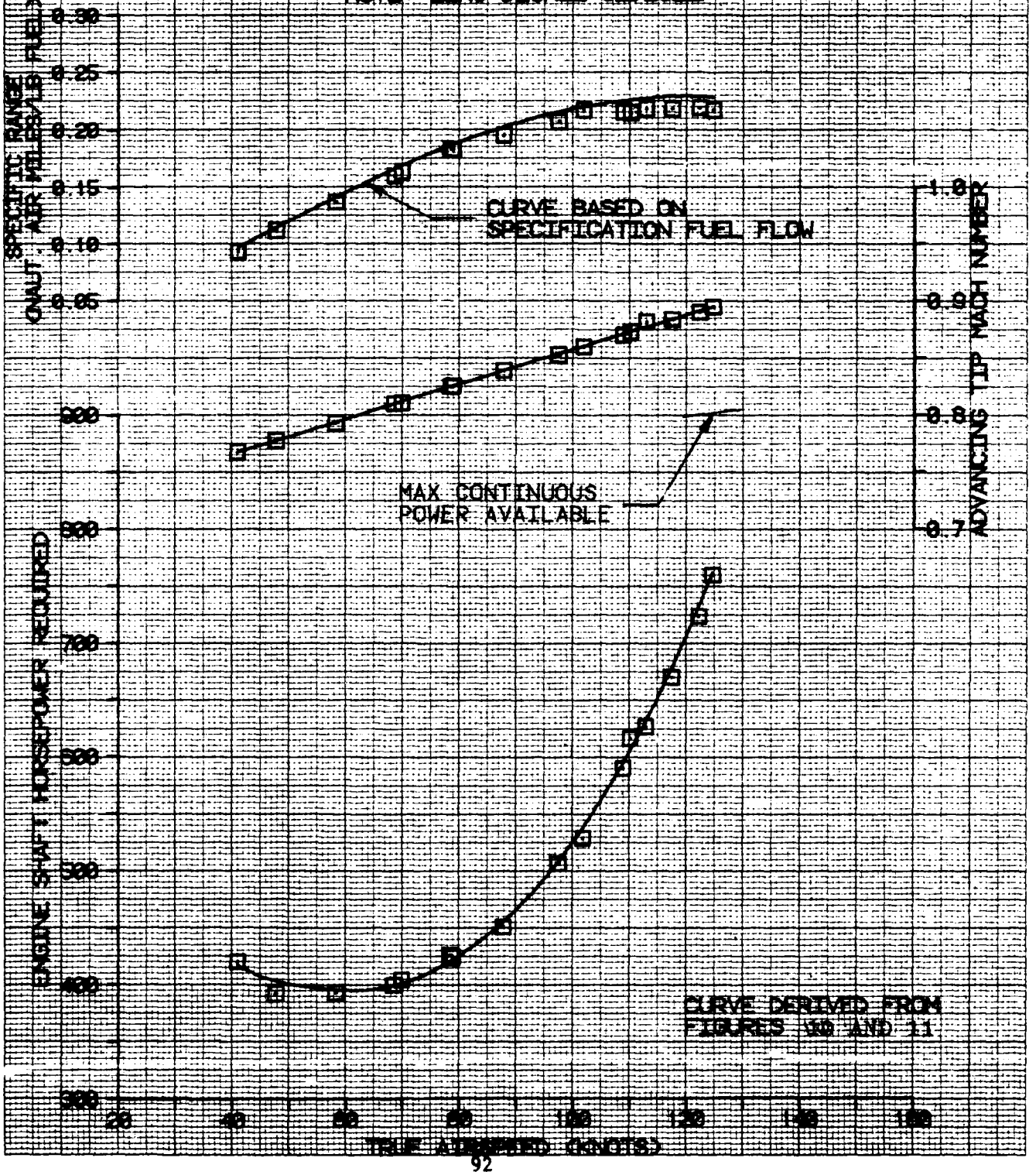


FIGURE 12227
LEVEL FLIGHT PERFORMANCE
UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	C.G. LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALTITUDE (FEET)	AVG O A T (DEG.C)	AVG REF. ROTOR SPEED (RPM)	AVG C_T	CONFIGURATION
7800	132.7(FWD)	0	7330	16.5	314.1	0.003608	PROD CMRB/ HUB SPRNG

NOTE: ZERO DEGREE SIDESLIP

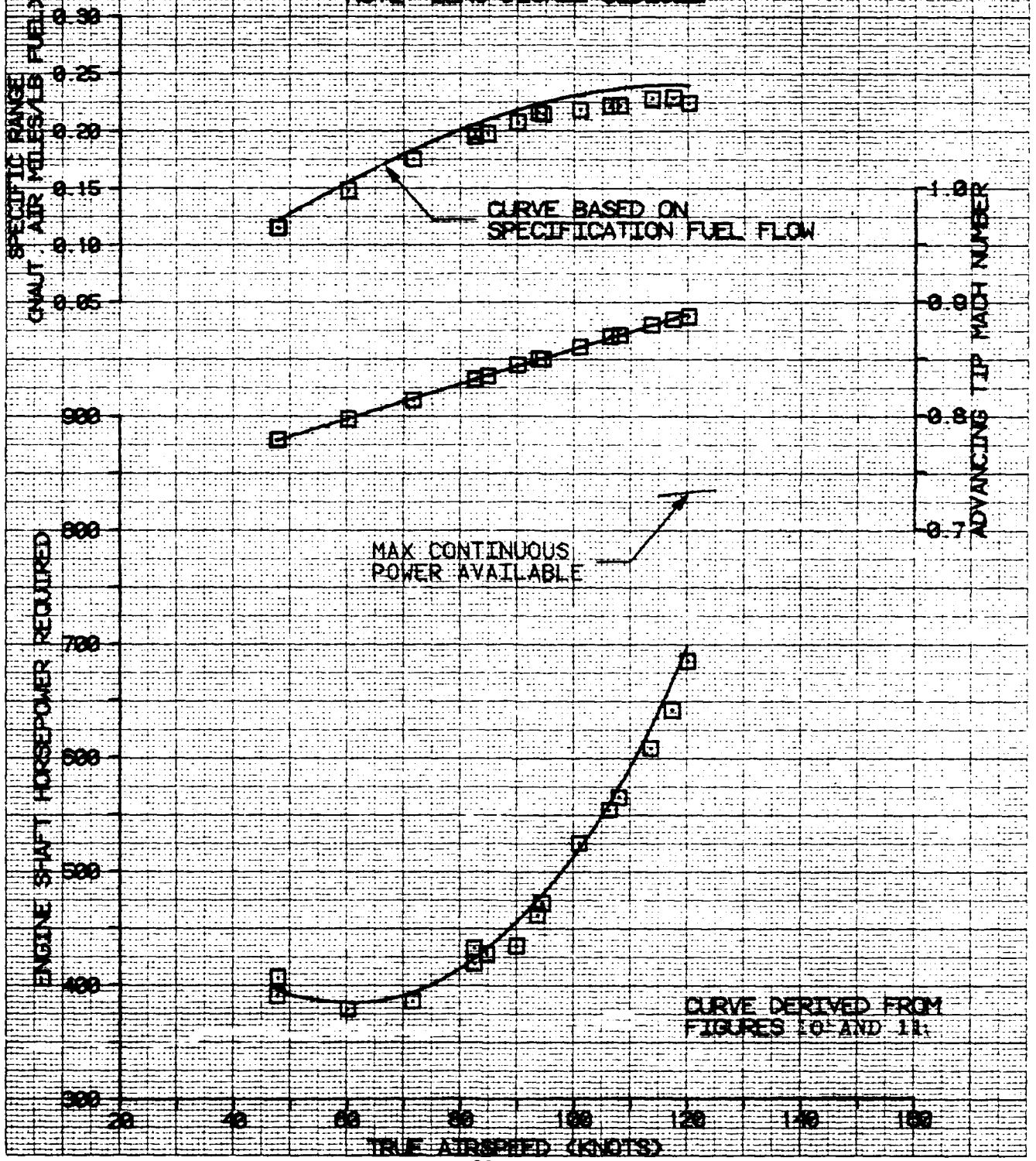


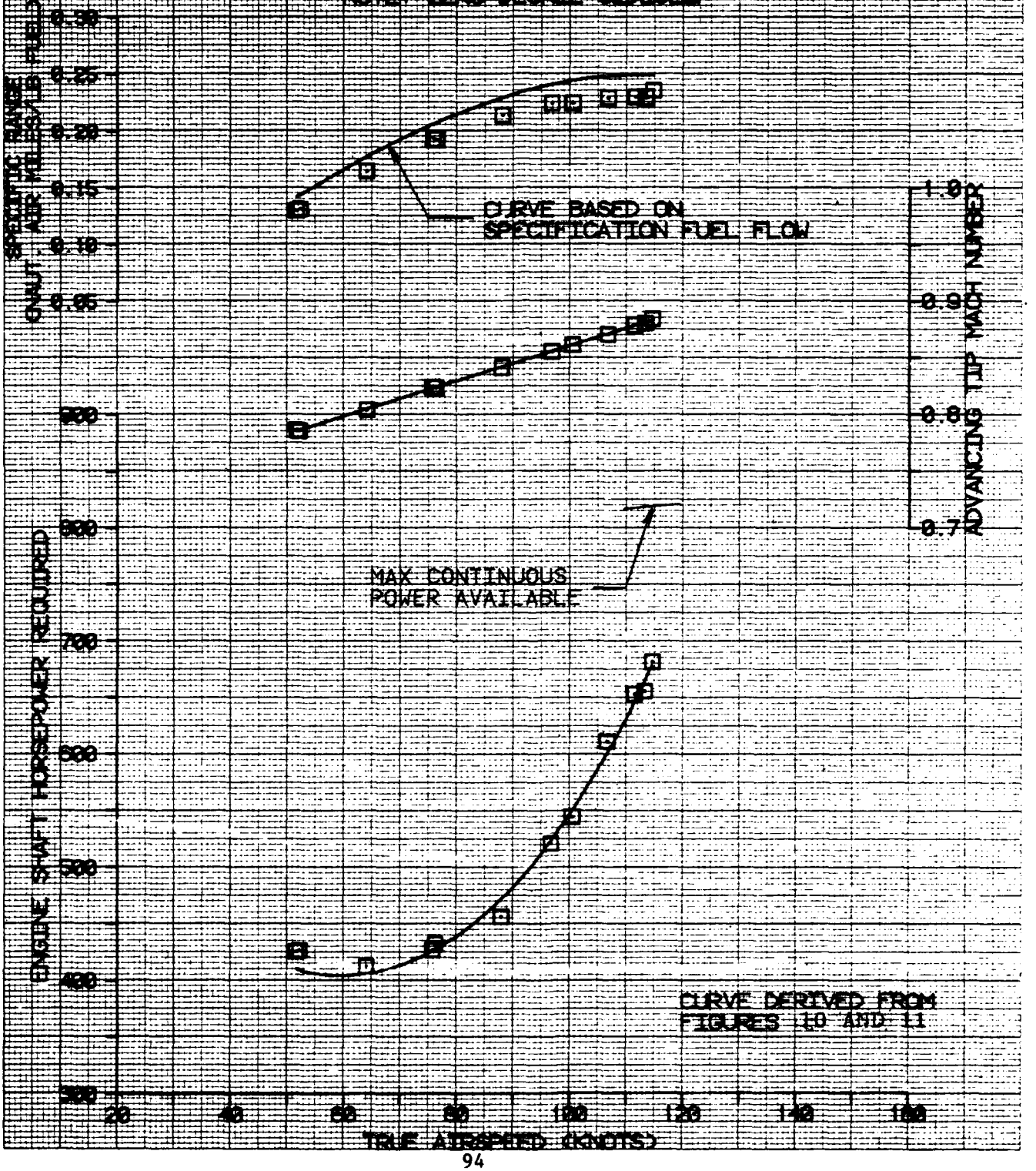
FIGURE X-24a

LEVEL FLIGHT PERFORMANCE

OH-X USA SAN GP-1658

AVG GROSS WEIGHT (LBS)	C.G. LOCATION LONG (FSS)	LAT (BL)	AVG DENSITY ALTITUDE (FEET)	AVG O.A.T. (DEG C)	AVG ROT. SPEED (RPM)	AVG C_T	CONFIGURATION
7000	138.3 CFWD	0 ILT	10550	6.5	314.0	0.004213	PROD CHRB/ HUB SPRING

NOTE: ZERO DEGREE SIDESLIP



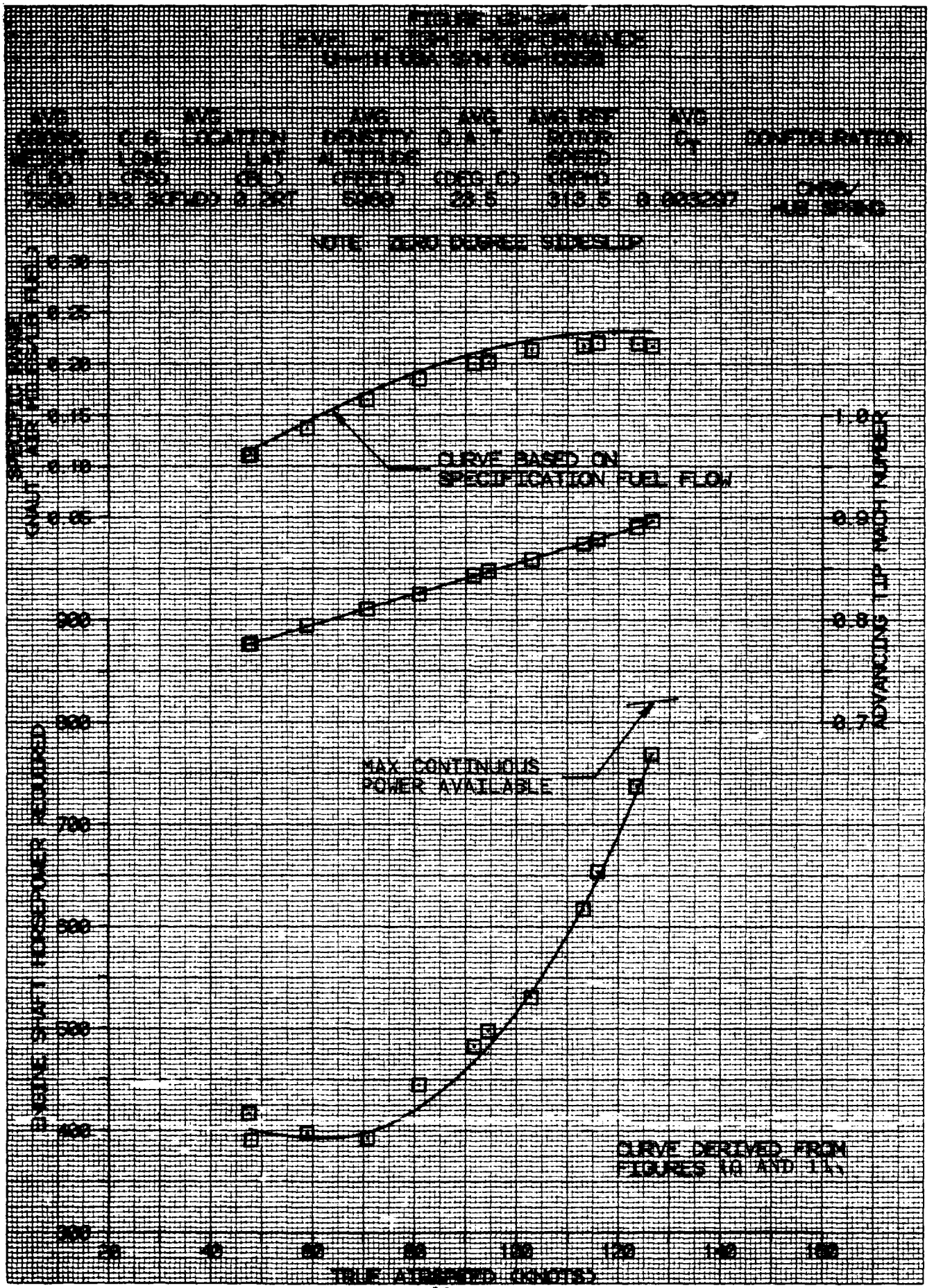
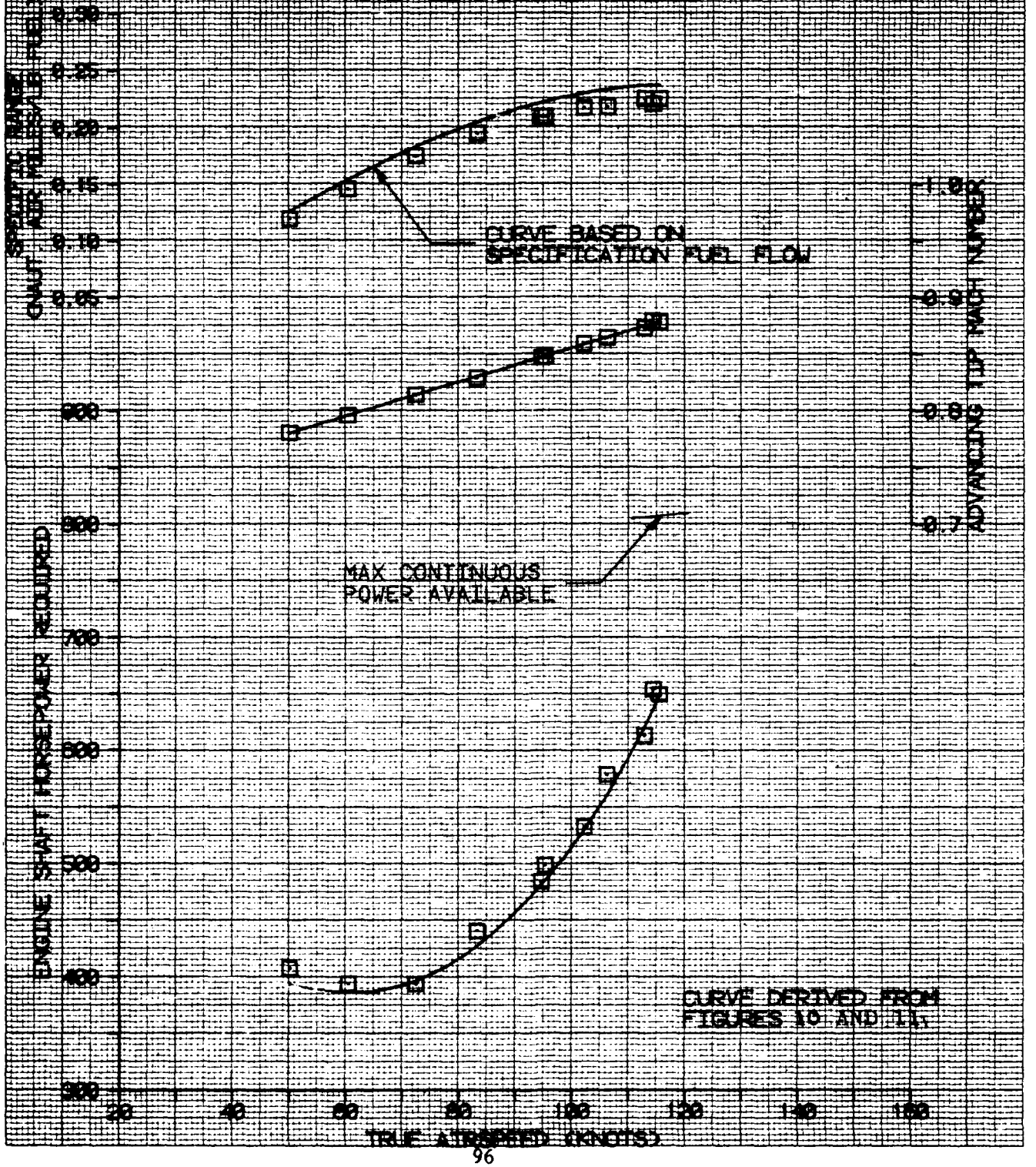

NOTE: ZERO DEGREE SIDESLIP
CURVE BASED ON SPECIFICATION FUEL FLOW
MAX CONTINUOUS POWER AVAILABLE
CURVE DERIVED FROM FIGURES 10 AND 11
TRUE AIRSPEED (KNOTS)
ADVANCING TIP MACH NUMBER
0.30
0.25
0.20
0.15
0.10
0.05
1.0
0.9
0.8
0.7
900
800
700
600
500
400
300
20
40
60
80
100
120
140
160

FIGURE B-23-2

LEVEL FLIGHT PERFORMANCE

AVG GROSS WEIGHT (LBS)	AVG C.G. LOCATION LONG (FSD)	LAT (BL)	AVG DENSITY ALTITUDE (FEET)	AVG O.A.T. (DEG.C)	AVG REF ROTOR SPEED (RPM)	AVG C_T	CONFIGURATION
7630	133 (GFWD)	0 (LT	7410	19.5	313.3	0.0006612	CHSC/ HUB SPRNG

NOTE: ZERO DEGREE SIDESLIP



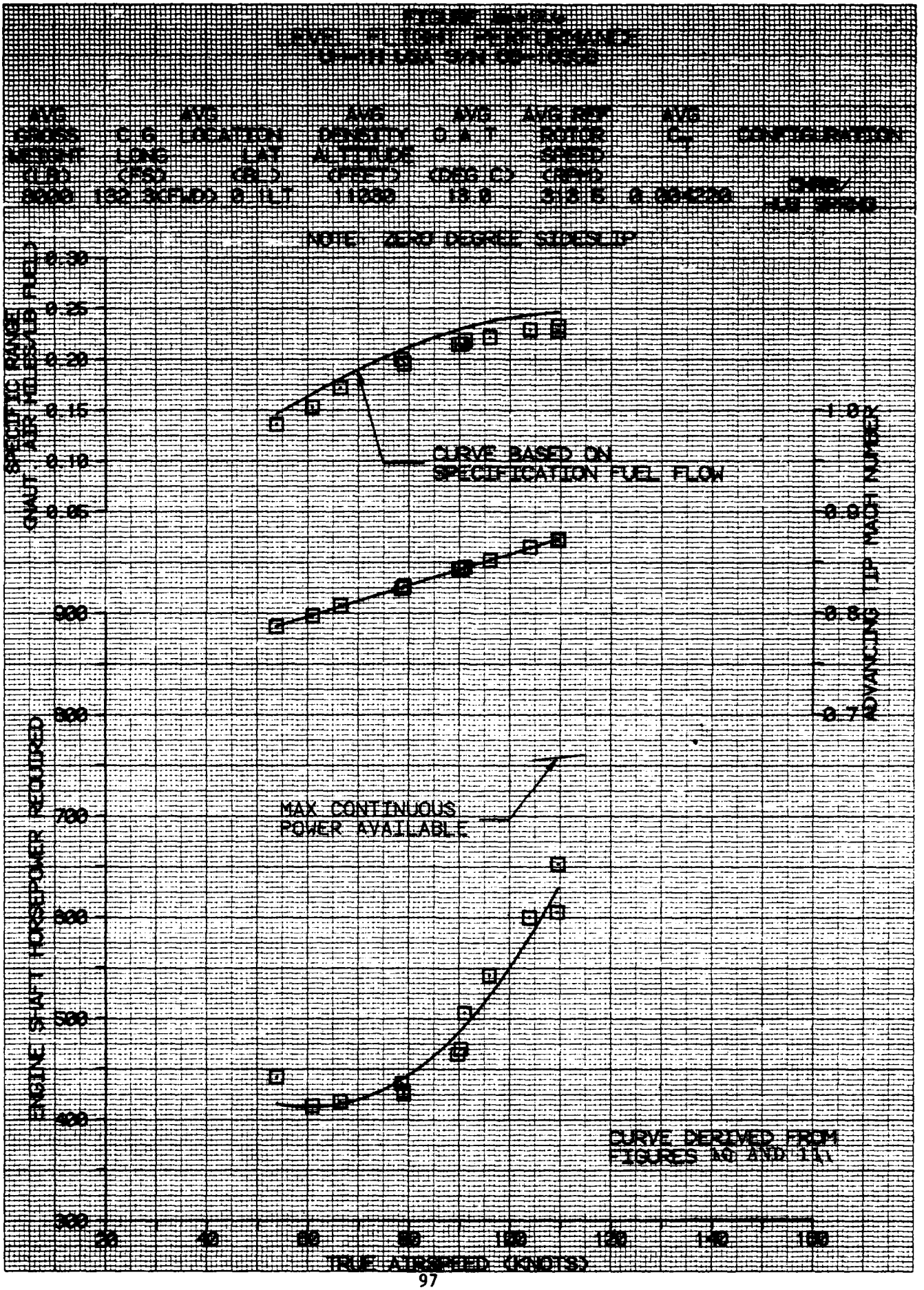

AVG GROSS WEIGHT (LB)
AVG C.G LOCATION LONG (FS)
AVG C.G LOCATION LAT (BL)
AVG DENSITY ALTITUDE (FEET)
AVG O.A.T (DEG C)
AVG ACT ROTOR SPEED (RPM)
AVG C_T
CONFIGURATION
3000 132 (FLD) 0 (LT 11000 15.0 318.5 0.004250 CRUISE/ FLT SPEED
NOTE: ZERO DEGREE SIDESLIP
SPECIFIC RANGE AIR MILES/LB FUEL
0.30
0.25
0.20
0.15
0.10
0.05
CURVE BASED ON SPECIFICATION FUEL FLOW
ADVANCING TIP MACH NUMBER
1.0
0.9
0.8
0.72
ENGINE SHAFT HORSEPOWER REQUIRED
800
700
600
500
400
300
MAX CONTINUOUS POWER AVAILABLE
CURVE DERIVED FROM FIGURES 40 AND 111
20
40
60
80
100
120
140
160
TRUE AIRSPEED (KNOTS)

FIGURE 27-1
LEVEL FLIGHT PERFORMANCE
UH-1H USA S/N 66-16558

AVG GROSS WEIGHT (LBS)	AVG C.G. LOCATION LONG (FSS)	LAT (BL)	AVG DENSITY ALTITUDE (FEET)	AVG O A T (DEG C)	AVG REF ROTOR SPEED (RPM)	AVG C_T	CONFIGURATION
9510	133.0 (FWD)	0	10000	10.5	313.3	0.004525	CARGO/ HUB SPRNG

NOTE: ZERO DEGREE SIDESLIP

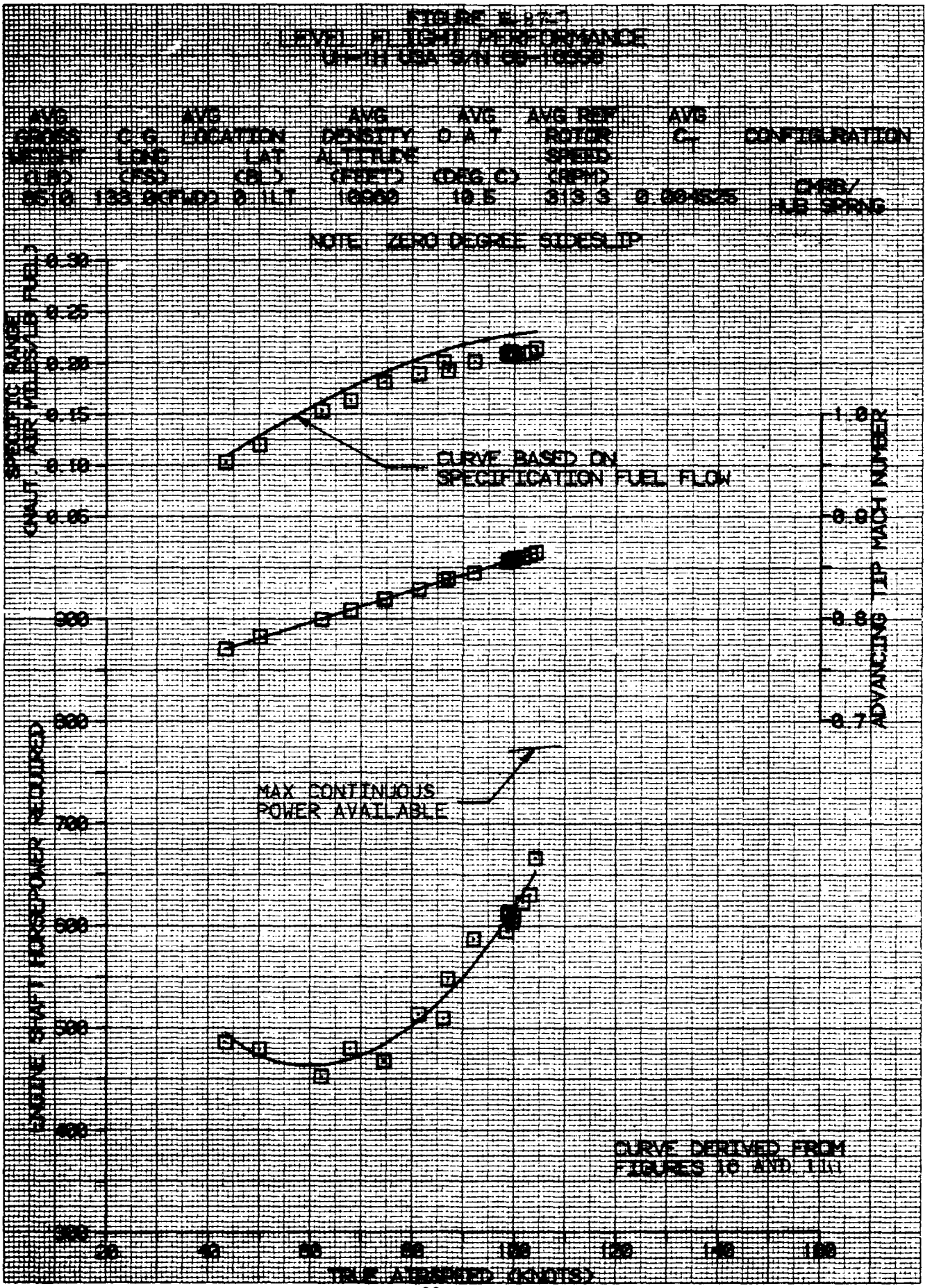


FIGURE [illegible]

LEVEL FLIGHT PERFORMANCE
UH-1H USA S/N 66-16558

AVG GROSS WEIGHT (LB)	AVG C.G. LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALTITUDE (FEET)	AVG O.A.T. (DEG C)	AVG REF ROTOR SPEED (RPM)	AVG C_T	CONFIGURATION
7200	133.2(FWD)	0.0	7530	7.0	323.8	0.003301	PROD CHIN/ HUB SPRING

NOTE: ZERO DEGREE SIDESLIP

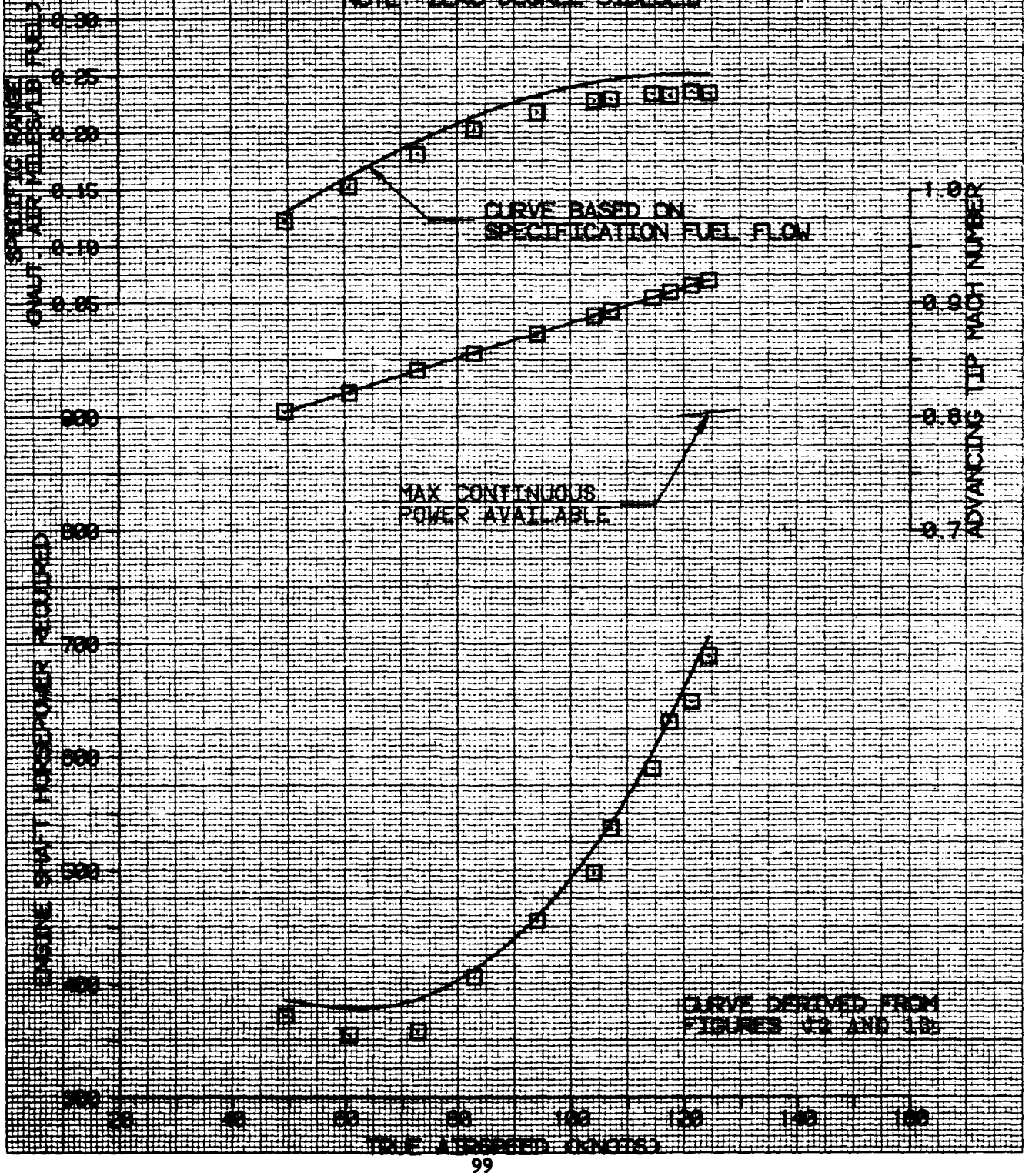


FIGURE 8a(23-4)

LEVEL FLIGHT PERFORMANCE
UH-1H USA S/N 69-16559

AVG GROSS WEIGHT (LBS)	AVG C.G. LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALTITUDE (FEET)	AVG O.A.T. (DEG.C)	AVG REF ROTOR SPEED (RPM)	AVG C_T	CONFIGURATION
8400	132.2(FWD)	0.0	5000	9.5	323.8	0.003594	PROD CHRD/ HUB SPRNG

NOTE: ZERO DEGREE SIDESLIP

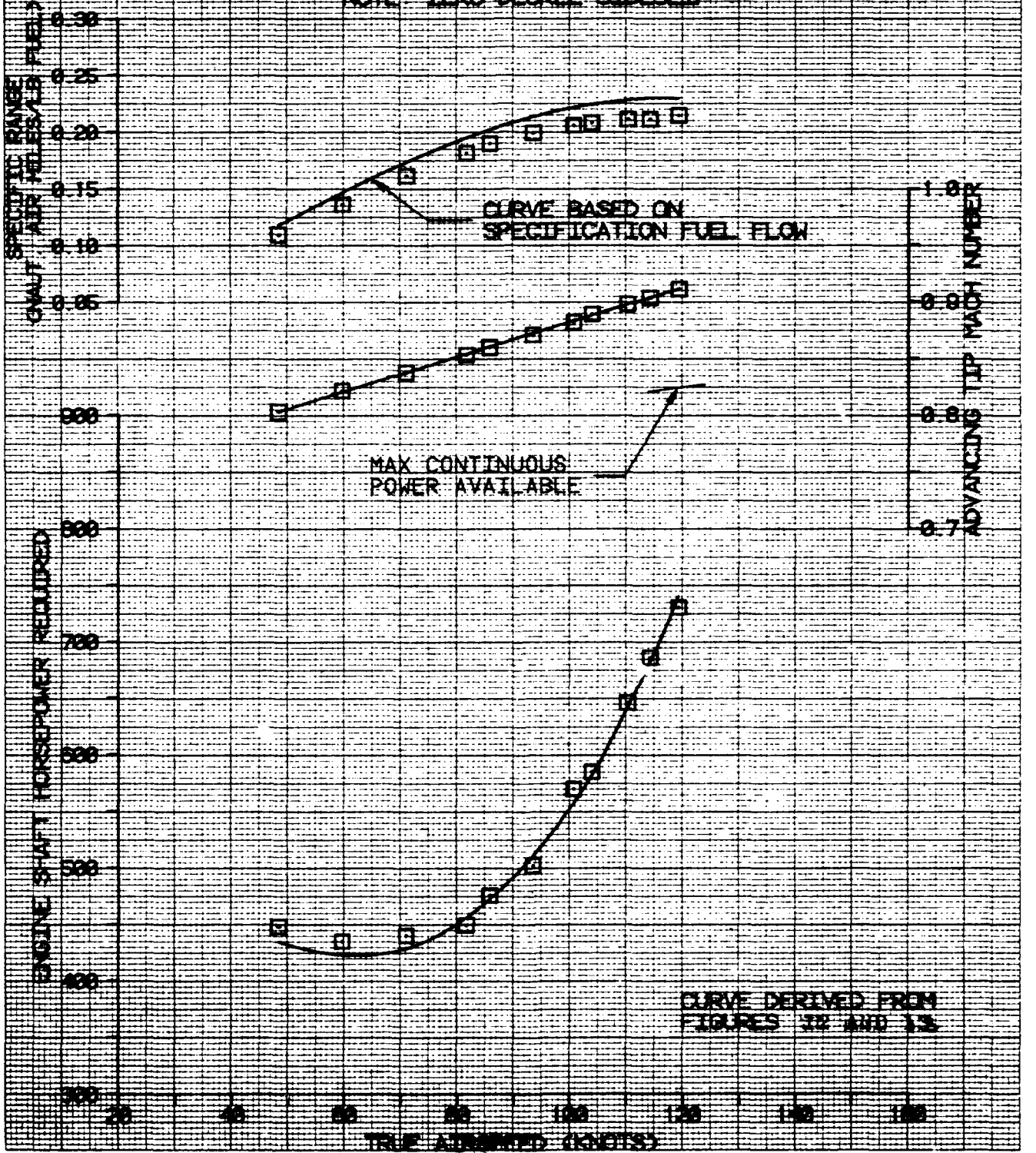


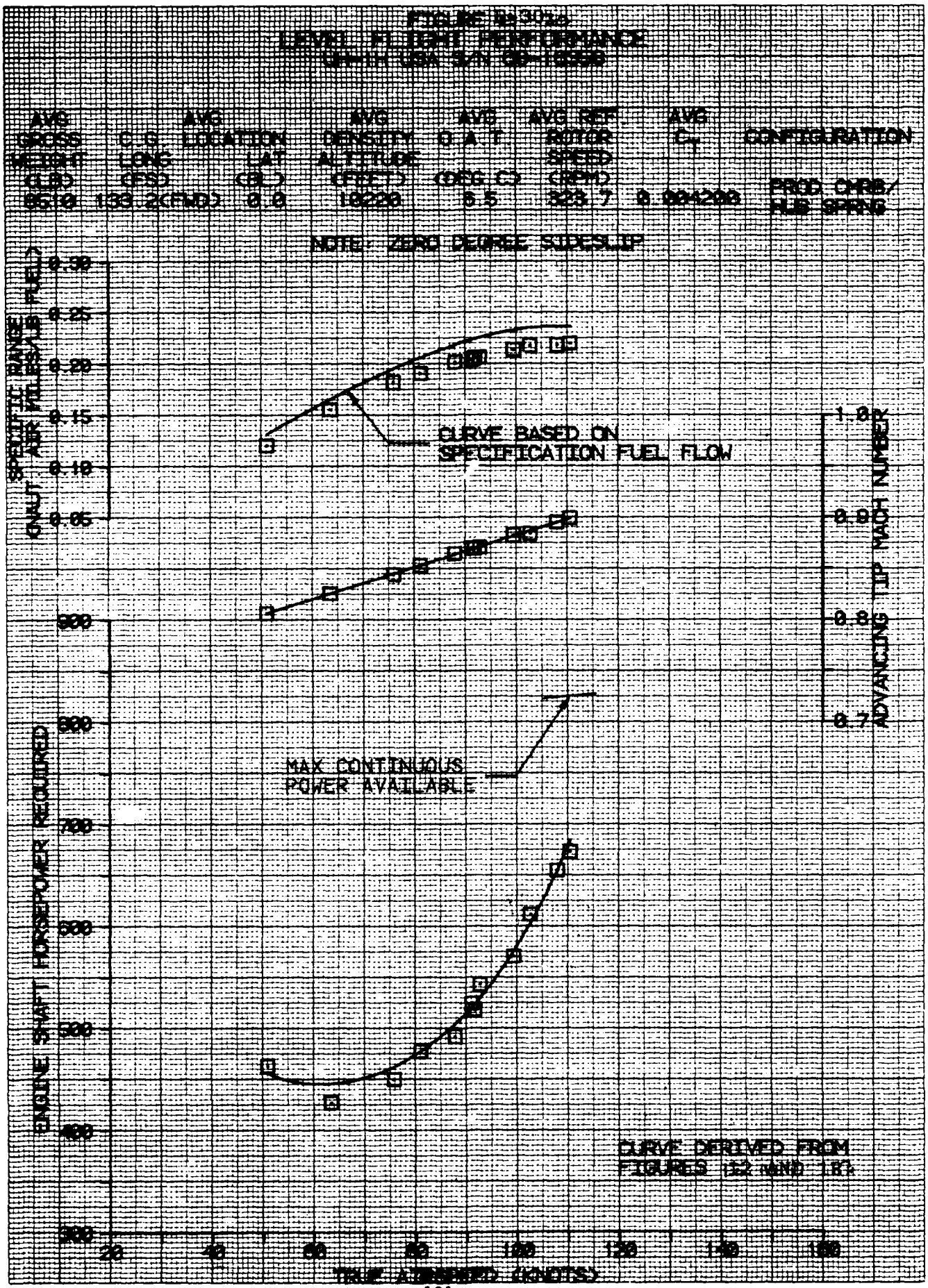
FIGURE 5-30(c)

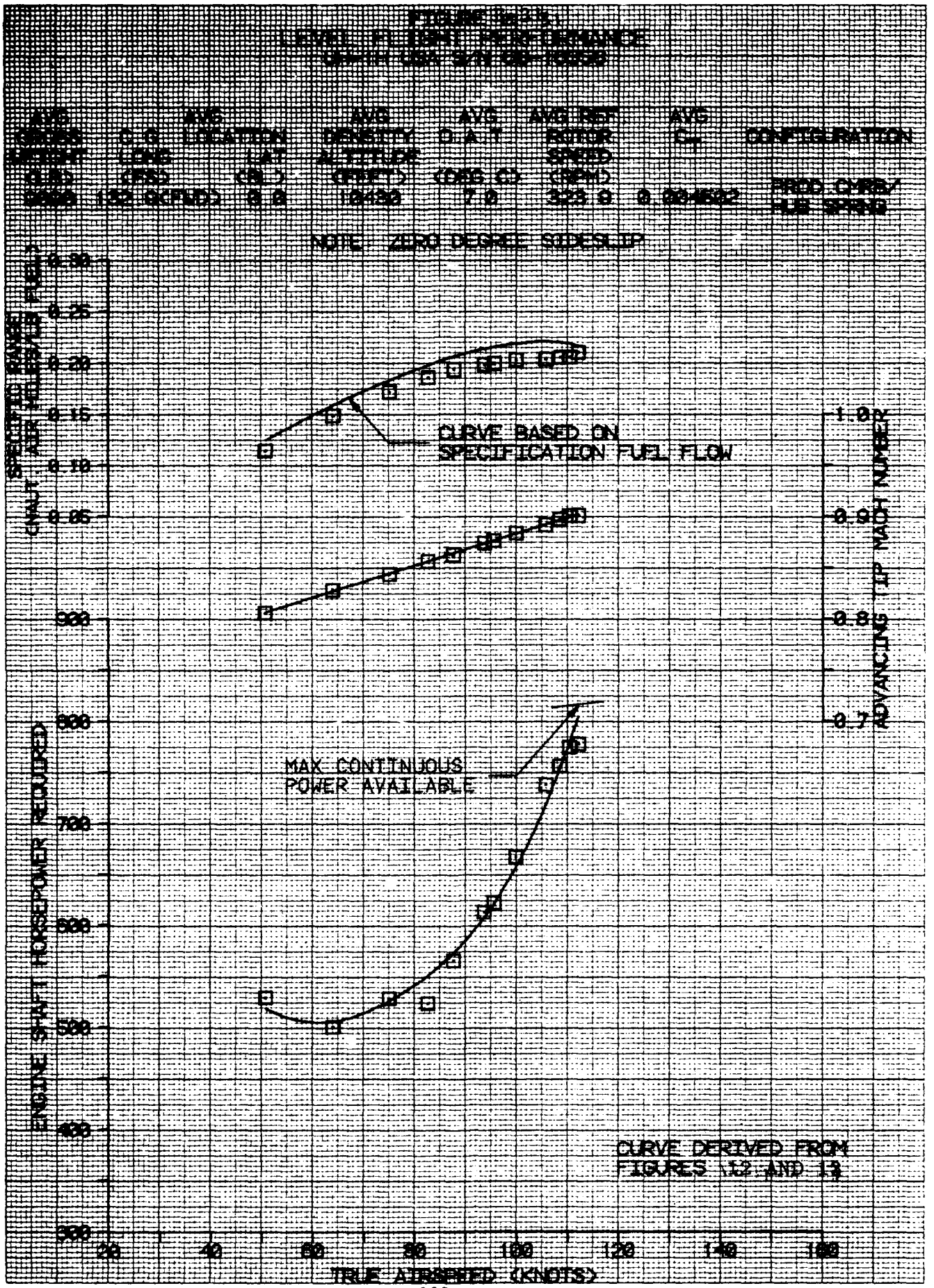
LEVEL FLIGHT PERFORMANCE

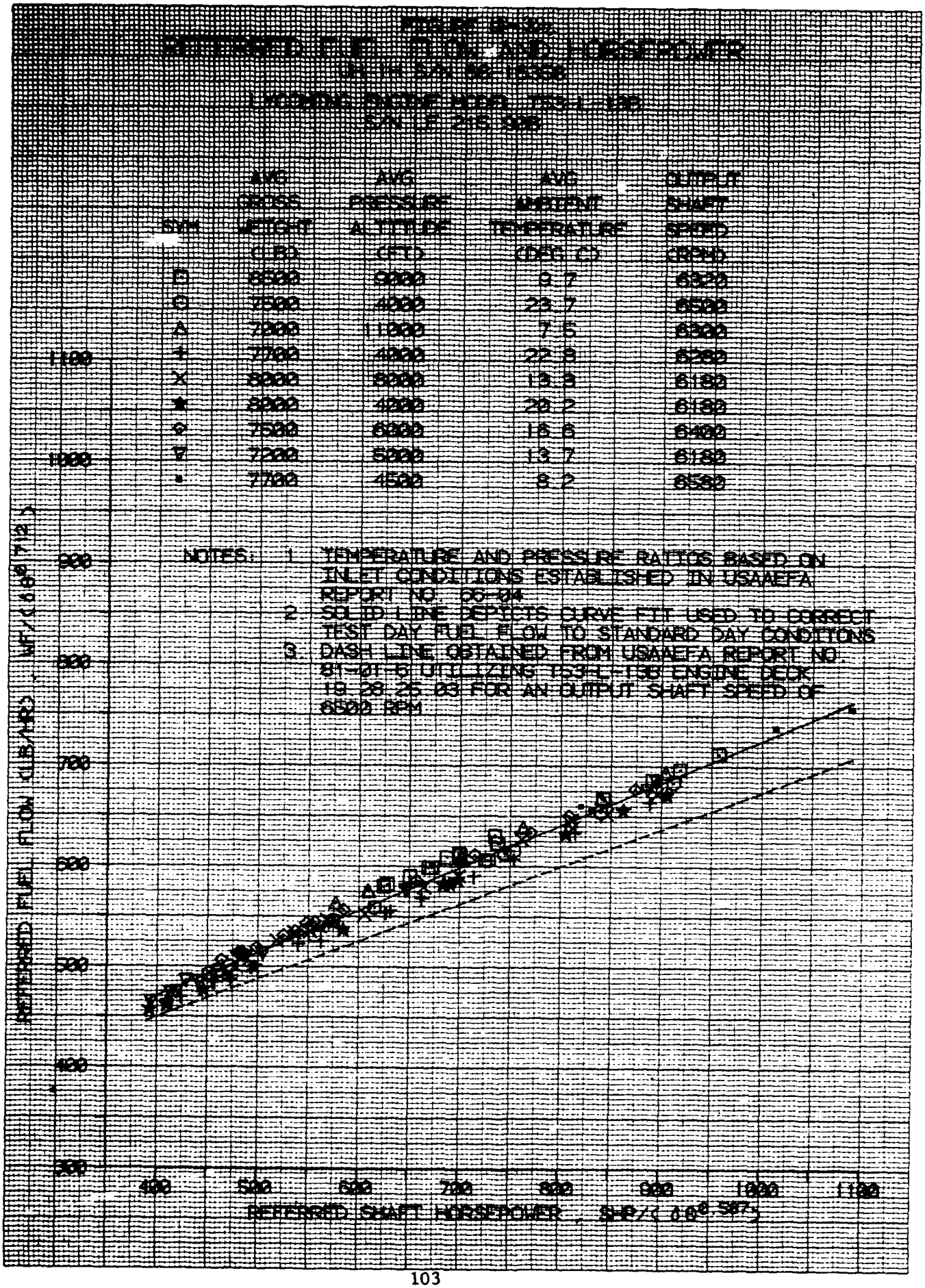
UH-1H USA S/N 66-16998

AVG GROSS WEIGHT (LB)	AVG C.G. LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALTITUDE (FEET)	AVG O A T (DEG C)	AVG REF ROTOR SPEED (RPM)	AVG C_T	CONFIGURATION
6510	133.2(FWD)	0.0	10220	0.5	323.7	0.004200	PROD CHRB/ HUB SPRNG

NOTE: ZERO DEGREE SIDESLIP




NOTE ZERO DEGREE SIDESLIP
CURVE BASED ON SPECIFICATION FUEL FLOW
MAX CONTINUOUS POWER AVAILABLE
CURVE DERIVED FROM FIGURES 12 AND 13
ADVANCING TIP MACH NUMBER
ENGINE SHAFT HORSEPOWER REQUIRED
TRUE AIRSPEED (KNOTS)
0.30
0.25
0.20
0.15
0.10
0.05
1.0
0.9
0.8
0.7
900
800
700
600
500
400
300
20
40
60
80
100
120
140
160



SYM	AVG GROSS WEIGHT (LBS)	AVG PRESSURE ALTITUDE (FT)	AVG AMBIENT TEMPERATURE (DEG C)	OUTPUT SHAFT SPEED (RPM)
□	8500	3000	9.7	6620
○	7900	4000	23.7	6580
△	7800	11000	7.5	6560
+	7700	4000	22.8	6580
×	8000	8000	13.3	6180
★	8000	4000	20.2	6180
◇	7500	6000	16.6	6400
▽	7200	5000	13.7	6182
▪	7700	4500	8.2	6580

AUTOROTATIONAL DESCENT PERFORMANCE

(AH-1H HSA S/N 66-15350)

SYM	AVG GROSS WEIGHT (LBS)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	AVG C_T
□	7700	182.8(+0.0)	0.0	10000	12.0	313	0.006502
△	7700	182.8(+0.0)	0.0	5000	3.0	300	0.006365

NOTES: 1. PROD CHORD/HUB SPRING CONFIGURATION
2. ZERO DEGREE SIDESLIP

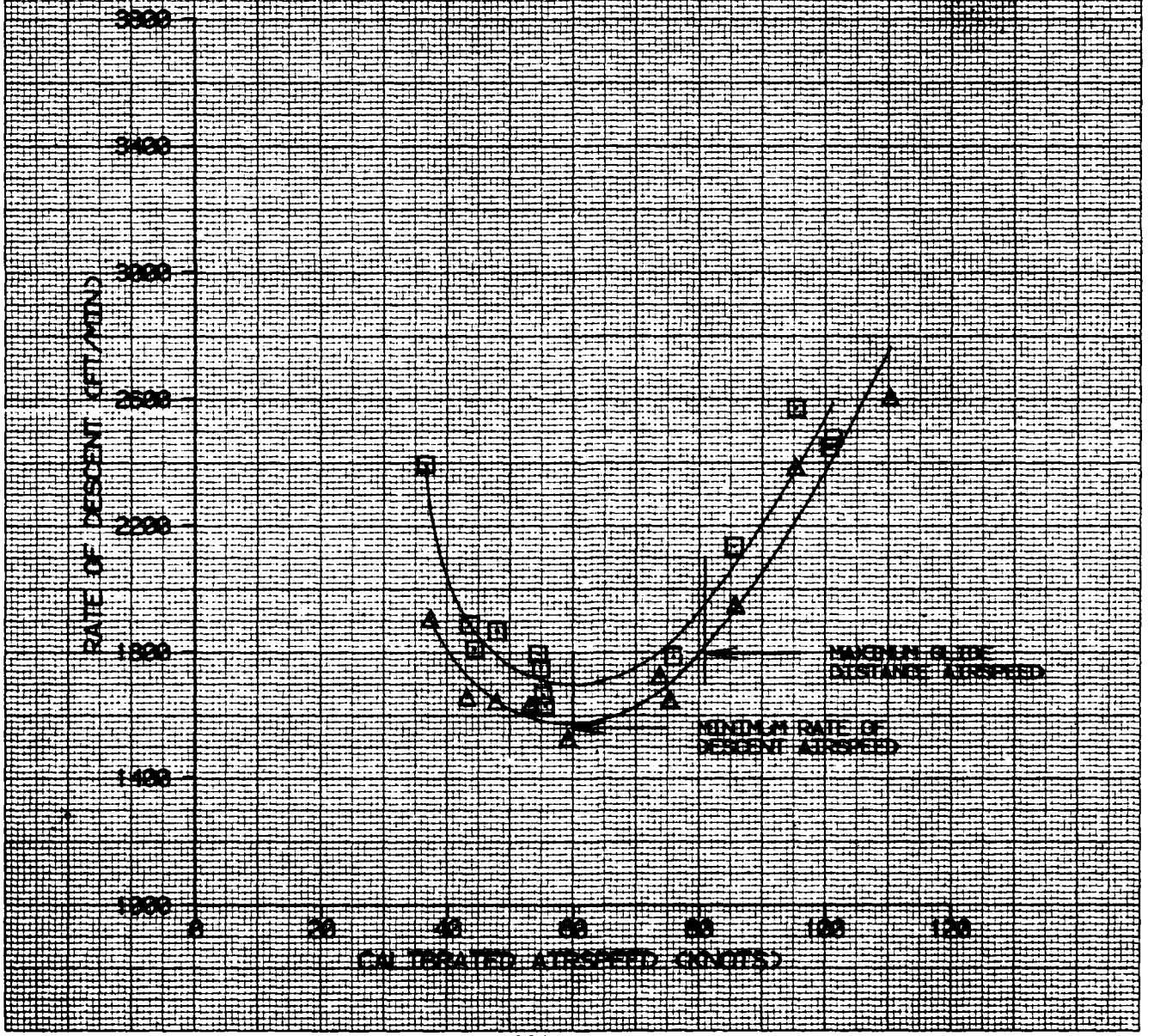


FIGURE B-19A

AUTOROTATIONAL DESCENT PERFORMANCE

UH-1H USA S/N 68-16656

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG CALIBRATED AIRSPEED (KT)
□	7700	132.3(FWD)	0.0	10000	12.0	55
△	7700	132.8(FWD)	0.0	5000	8.0	59

NOTES: 1. PROD DMBR/HUB SPRNG CONFIGURATION
2. ZERO DEGREE SIDESLIP

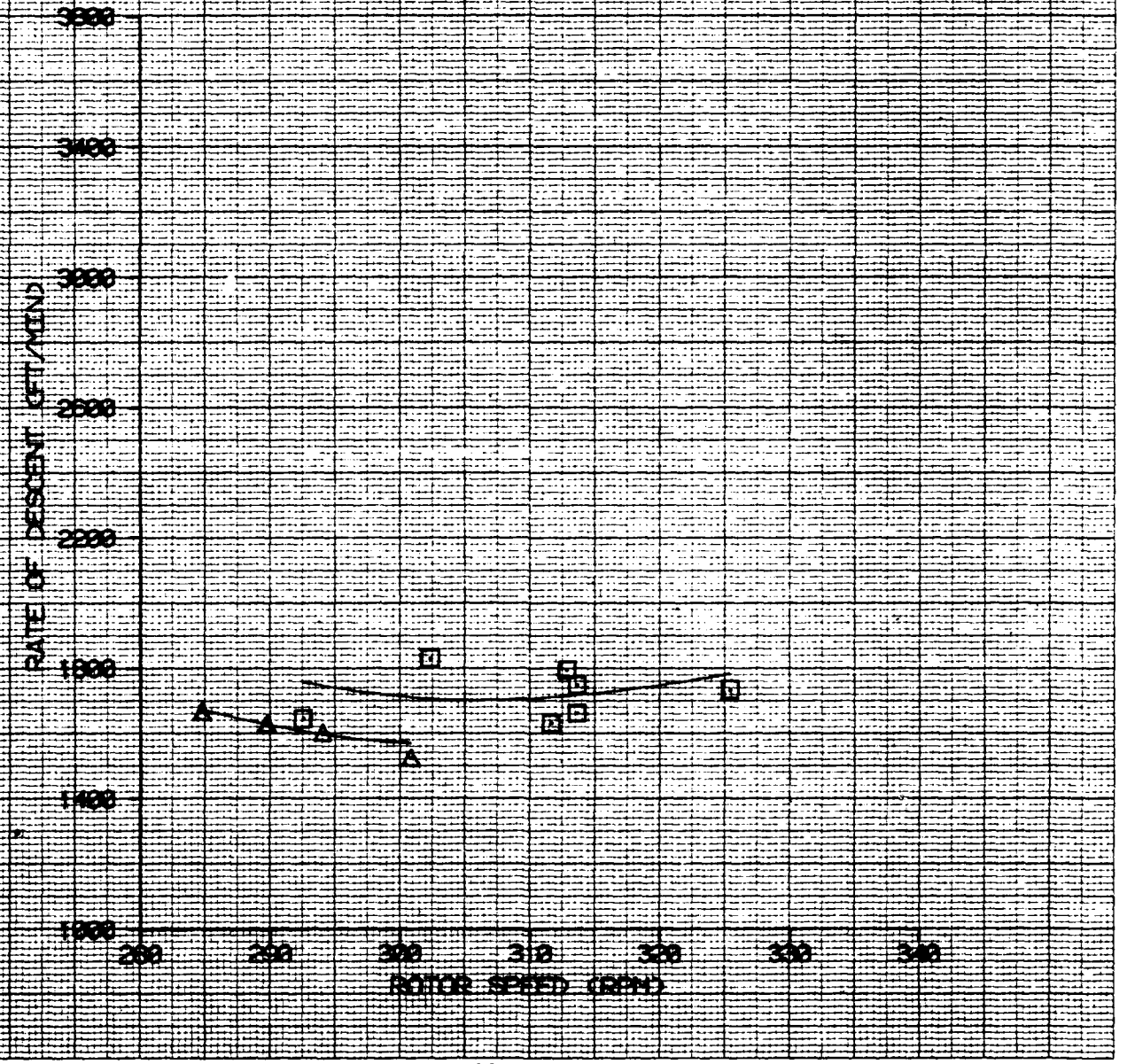


FIGURE E-35

CONTROL POSITIONS IN TRIMMED FOWARD FLIGHT

UH-1H USA S/N 68-16358

SYM	AVG GROSS WEIGHT (LBS)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	AIRCRAFT CONFIGURATION
⊡	8400	142.8(AFT)	0.0	6000	0.0	314	LEVEL	CHRB/HUB SPRNG
⊙	8500	133.8(FWD)	0.0	10000	10.5	311	LEVEL	CHRB/HUB SPRNG

NOTE: HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

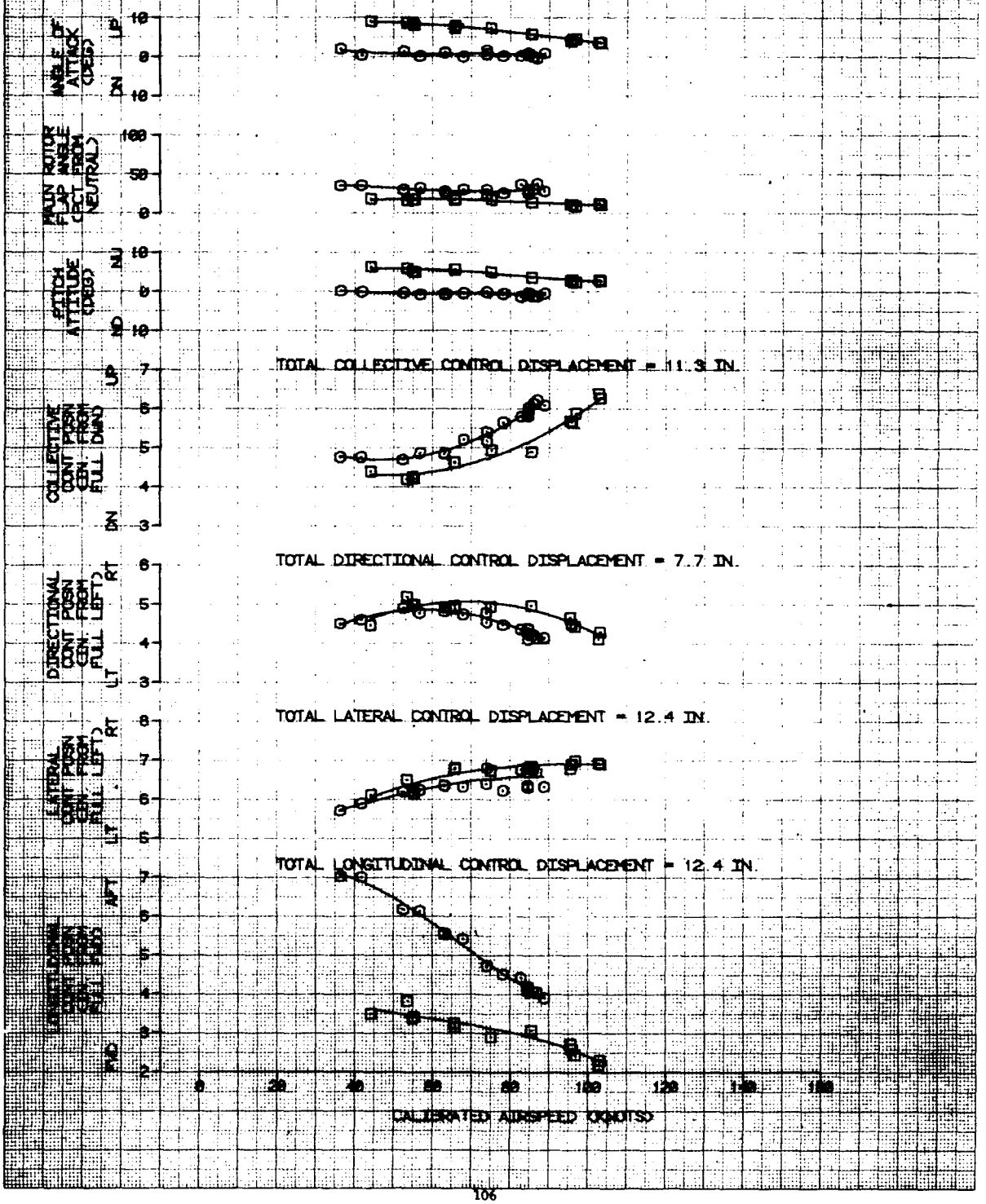


FIGURE 3-36

CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT

UH-1H USA S/N 68-15953

SYM	AVG GROSS WEIGHT (LBS)	AVG CG LOCATION LONG (STA)	LAT (IN.)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	AIRCRAFT CONFIGURATION
⊡	7640	132.1 (CMAC)	0.0	4520	19.5	323	LEVEL	CMBS/HUB SPRNG
⊟	8000	130.9 (CMAC)	0.0	10000	10.5	311	LEVEL	CMBS/HUB SPRNG

NOTE: HUB SPRING ENGAGEMENT OCCURS AT 45K M/R FLAPPING

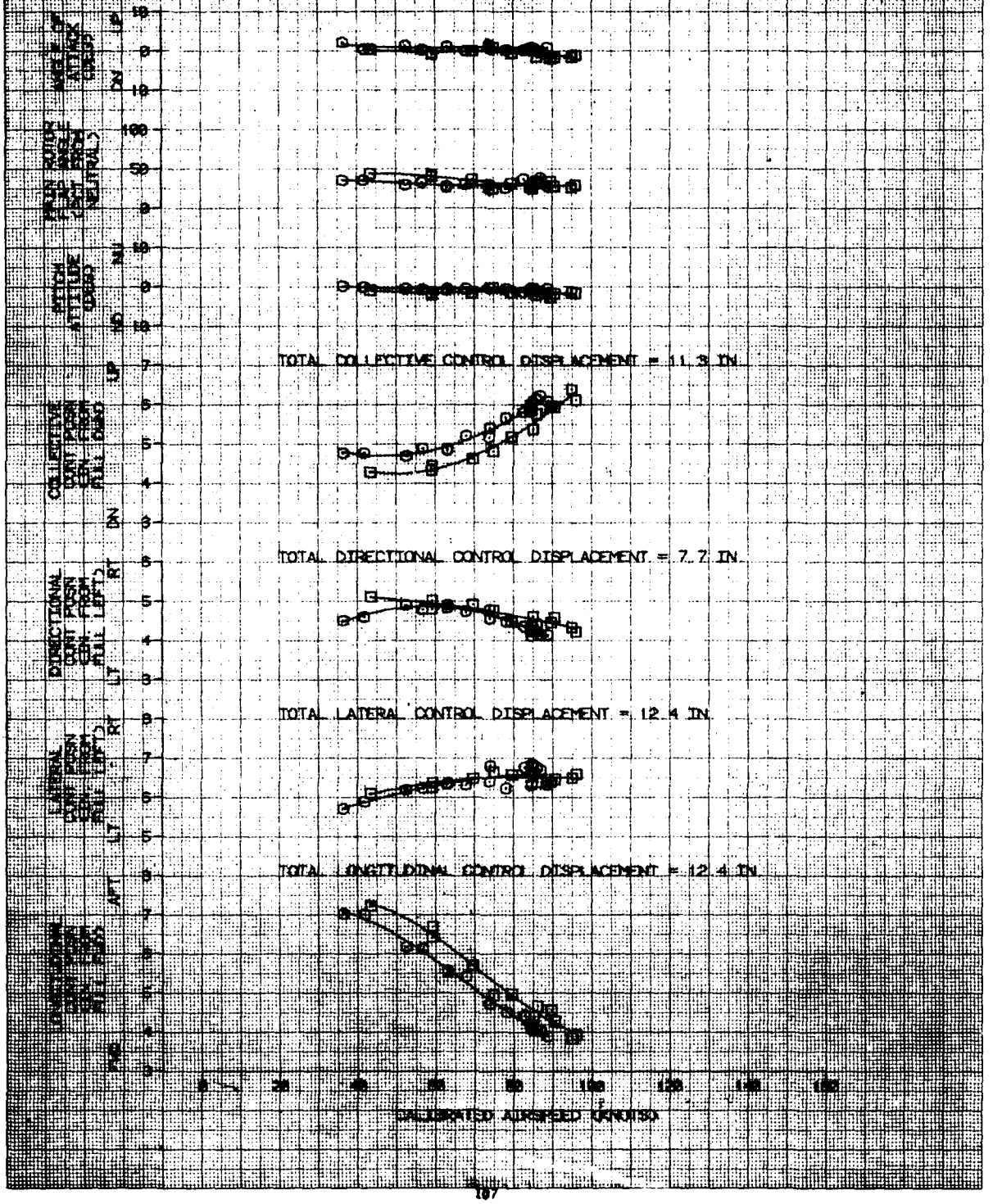


FIGURE 5-47

CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT

UH-1H USA S/N 68-16358

SYM	AVG GROSS WEIGHT (LBS)	AVG CG LOCATION LONG (BBL)	AVG CG LOCATION LAT (BBL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CONDITION	AIRCRAFT CONFIGURATION
□	7240	139.2(FWD)	0.0	6188	23.0	328	LEVEL	DASH/ALE SPRAY
◇	7289	139.2(FWD)	0.0	7898	7.0	319	LEVEL	FWD CARGO/ALE SPRAY

NOTE: HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

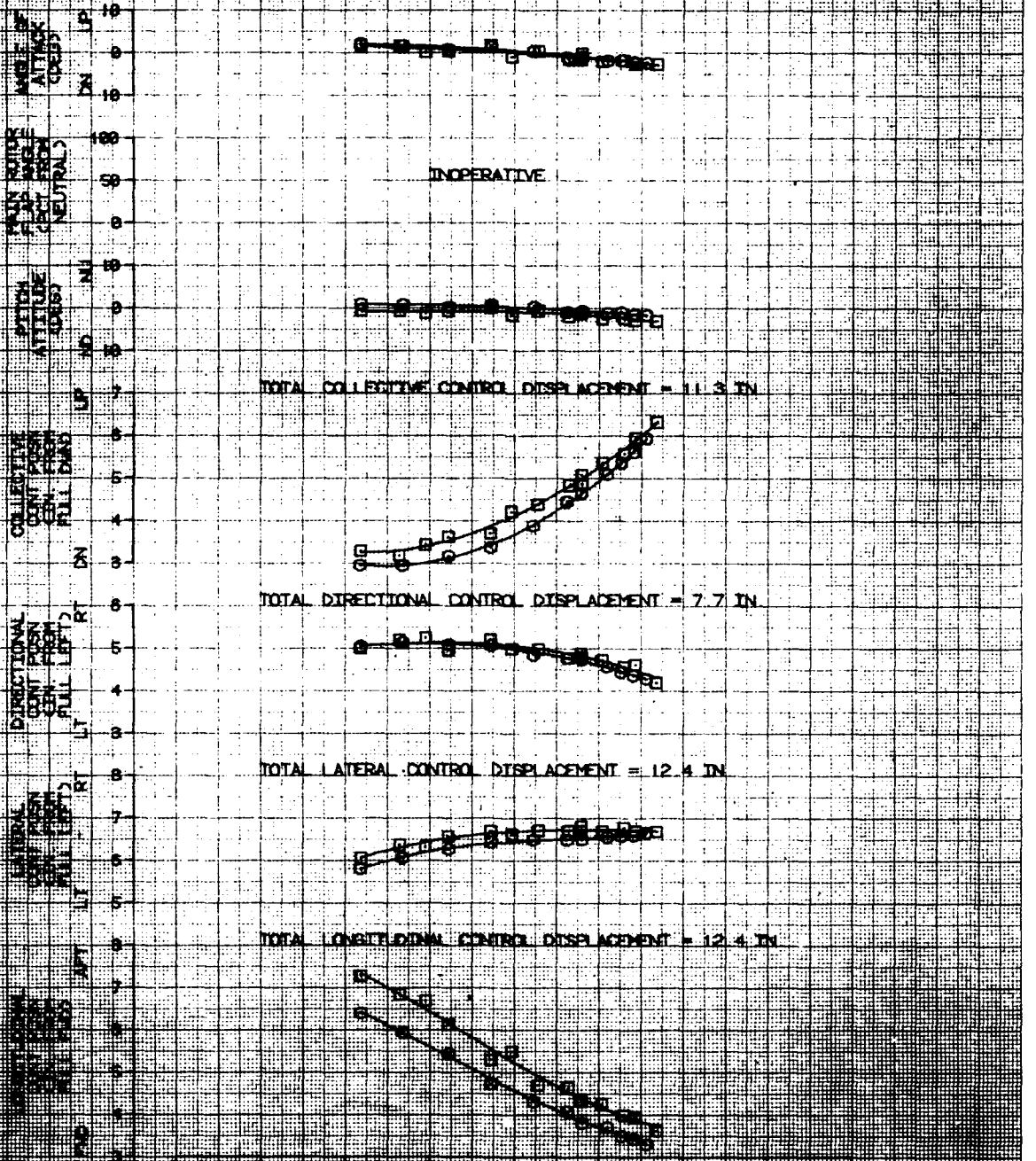


FIGURE E-38

CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT

UH-1H USA S/N 68-16358

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (BS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	AIRCRAFT CONFIGURATION
□	7340	139.1 (FWD)	0.0	4400	17.0	325	LEVEL	PROD CHOB/HUB SPRNG
○	7700	132.8 (FWD)	0.0	2180	13.5	323	LEVEL	CHOB/HUB SPRNG

NOTE: HUB SPRING ENGAGEMENT OCCURS AT 45K M/R FLAPPING

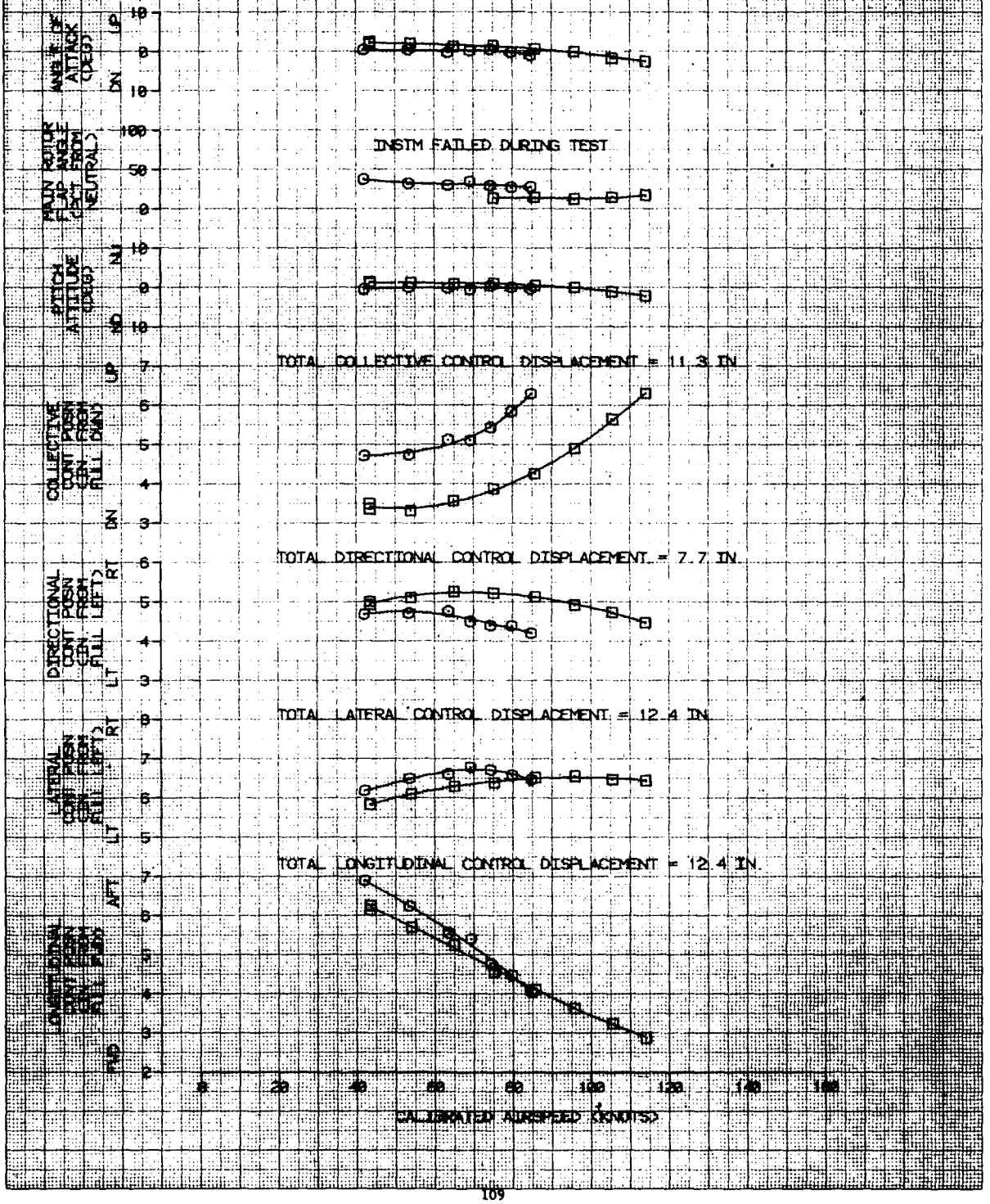


FIGURE E-39

CONTROL POSITIONS IN TRIMMED FOWARD FLIGHT

UH-1H USA S/N 68-16358

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	AIRCRAFT CONFIGURATION
⊡	7280	133.2(FWD)	0.0	7560	7.0	319	LEVEL	PROD CMRB/HUB SPRING
⊡	7740	132.3(FWD)	0.0	6760	12.0	322	LEVEL	STD/HUB SPRING

NOTE: HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

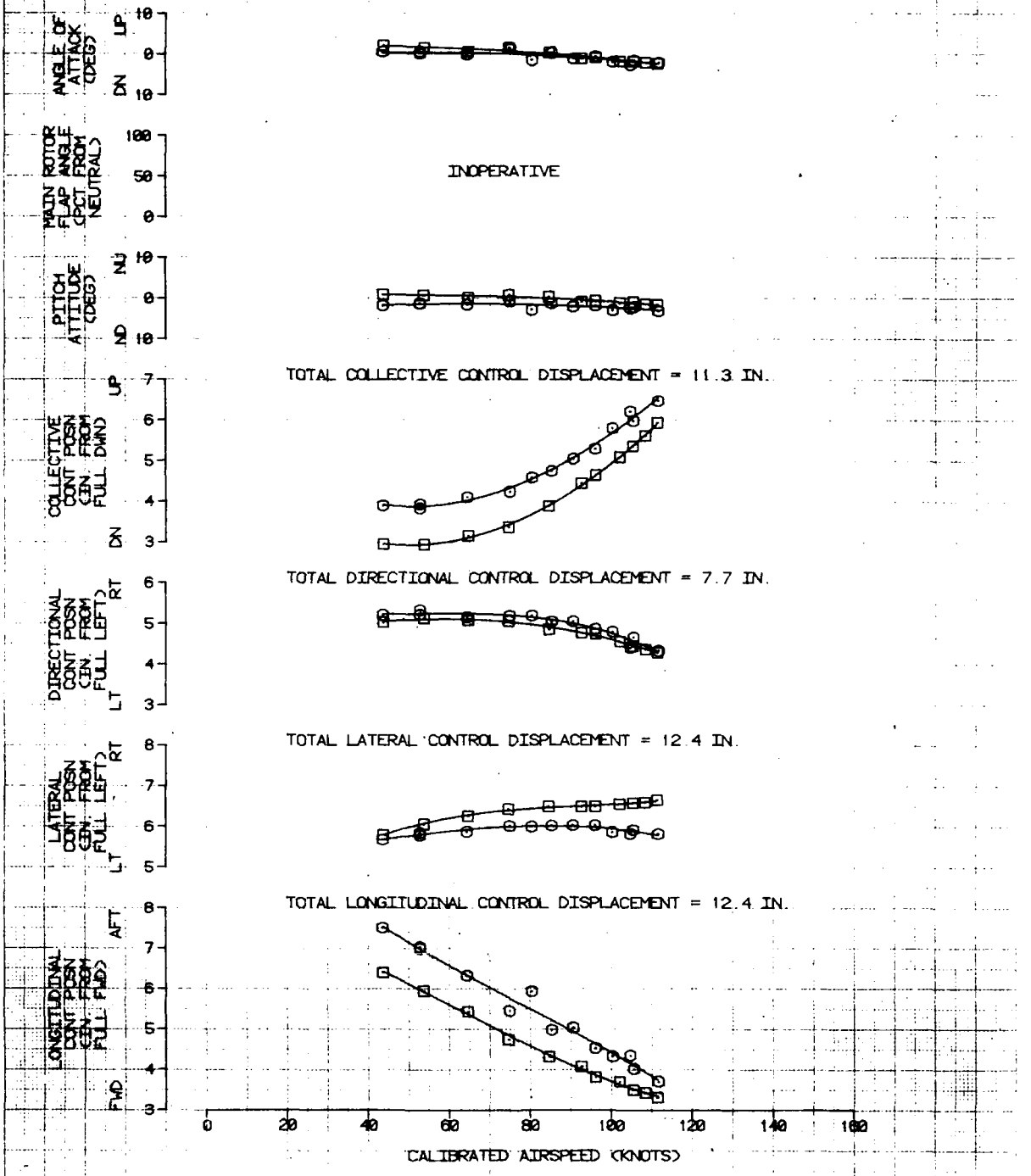


FIGURE A-40

EFFECTIVE-FIXED STATIC LONGITUDINAL STABILITY

UH-1H USA S/N 68-16858

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION
●	9640	133.2 (FWD)	0.0	5860	23.5	324	LEVEL
○	9440	132.4 (FWD)	0.0	6140	23.5	324	LEVEL

NOTES: 1. SOLID SYMBOLS DENOTE TRIM
2. CMRB/HUB SPRING CONFIGURATION
3. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

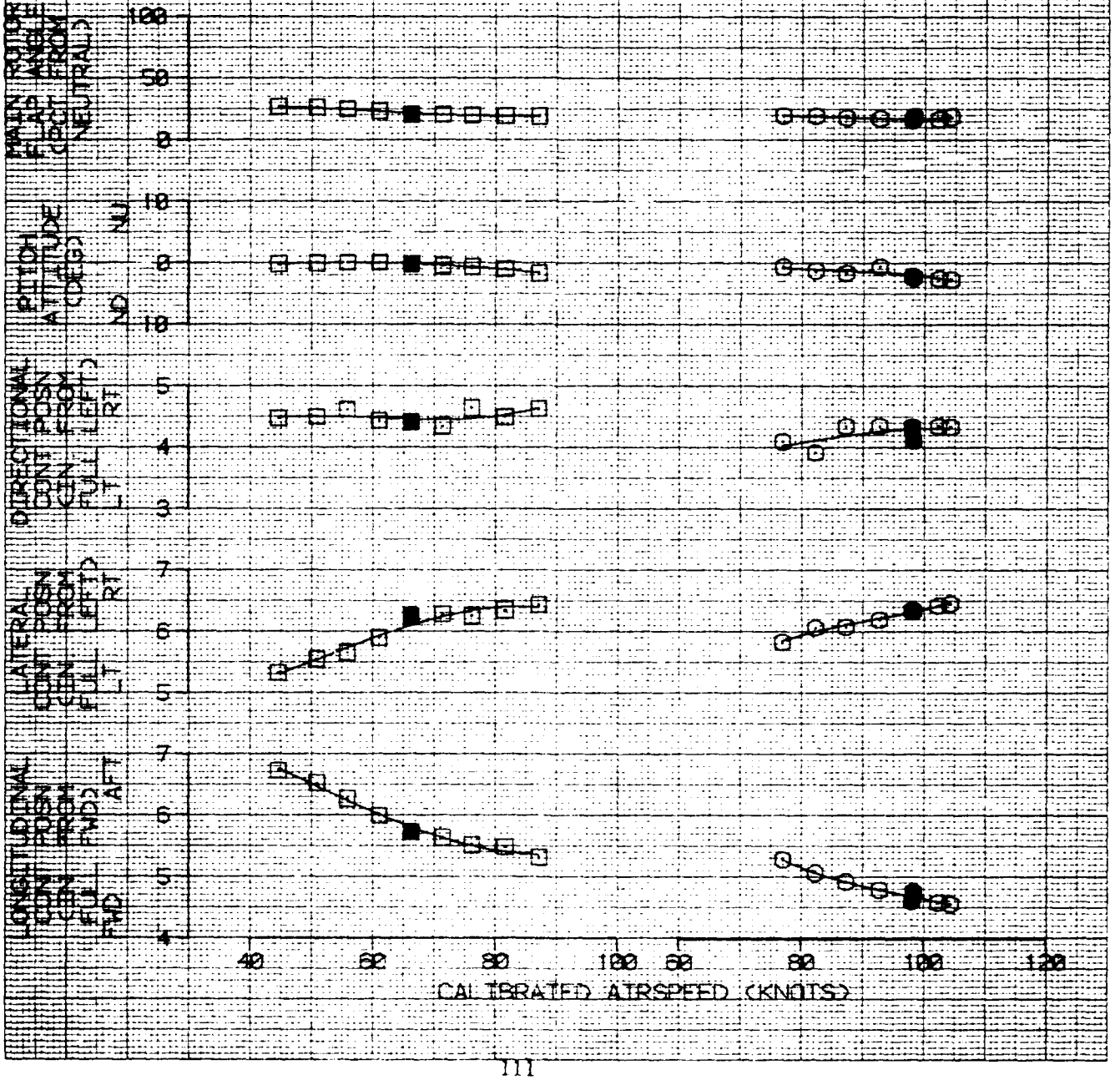


FIGURE 5-61

COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY

UH-1H USA S/N 66-16958

SYM	AVG GROSS WEIGHT (LBS)	AVG CG LOCATION LONG (FSTA)	LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TEST CONDITION
□	8400	142.1 (AFT)	0.0	6800	-2.5	314	LEVEL
○	8200	141.7 (AFT)	0.0	6200	-3.0	314	LEVEL

NOTES: 1. SOLID SYMBOLS DENOTE TRIM
2. DMRS/HUB SPRING CONFIGURATION
3. HUB SPRING ENGAGEMENT OCCURS AT 45K M/R FLAPPING

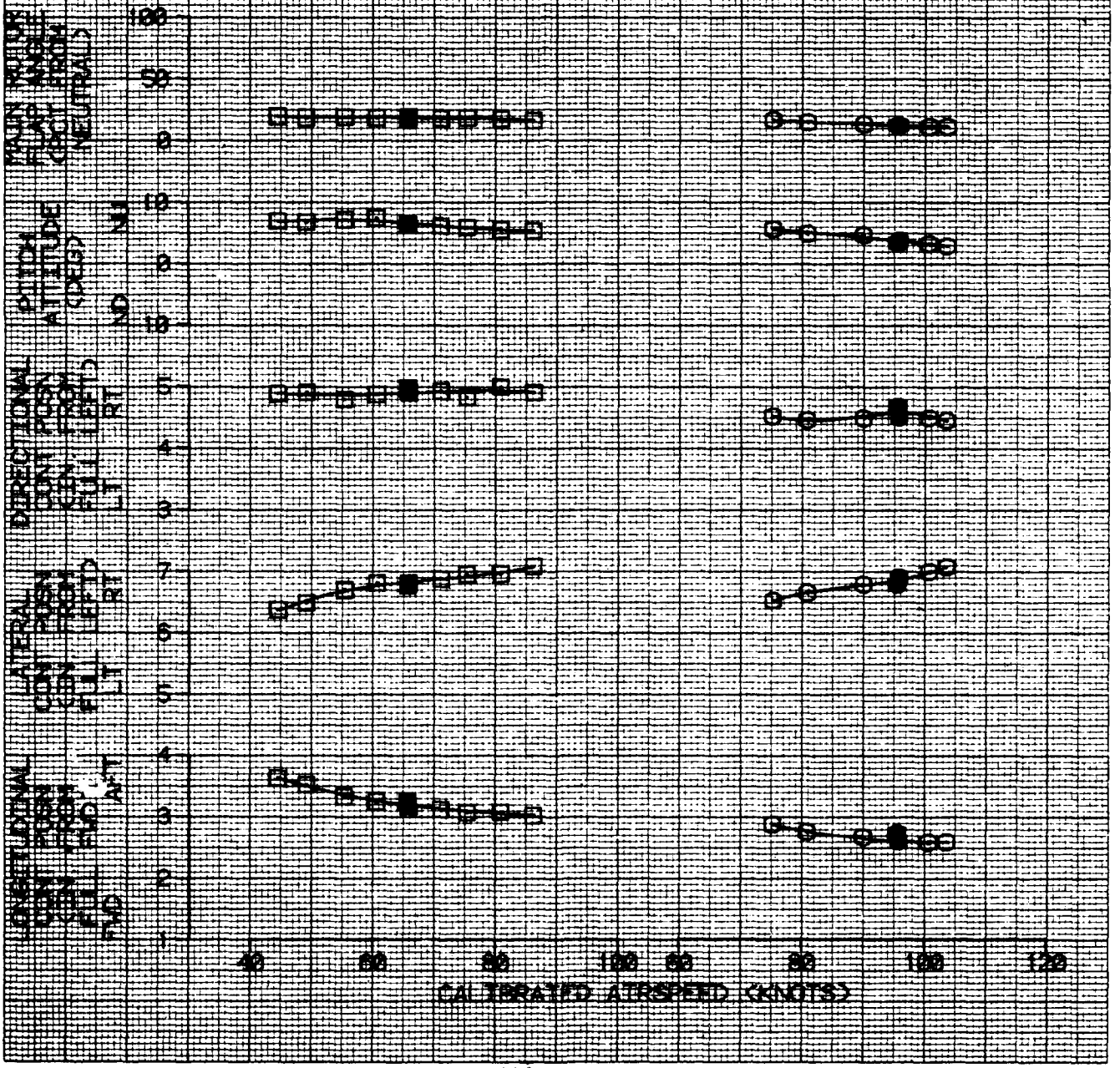


FIGURE 5-42

COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY

UH-1H USA S/N 68-8358

CONF	AVG GROSS WEIGHT (LBS)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION
□	8480	132.6 (FWD)	0.0	6000	1.0	323	1000 FPM CLMB
○	8440	132.4 (FWD)	0.0	5880	0.0	323	AUTO

NOTES: 1. SOLID SYMBOLS DENOTE TRIM
2. CMRB/HUB SPRING CONFIGURATION
3. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

MAIN ROTOR LONGITUDINAL CYCLIC STICK POSITION (PERCENT FROM FULL AFT)

PITCH ATTITUDE (DEG)

DIFFERENTIAL COLLECTIVE POSITION (INCHES FROM FULL UP)

LATERAL CYCLIC STICK POSITION (PERCENT FROM FULL RIGHT)

LONGITUDINAL CYCLIC STICK POSITION (PERCENT FROM FULL AFT)

CALIBRATED AIRSPEED (KNOTS)

FIGURE 5-43

COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY

UH-1H USA S/N 66-0958

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION
□	8340	141.4 (AFT)	0.0	6000	5.5	314	MAX PWR CLMB
○	8480	141.8 (AFT)	0.0	6020	0.0	313	AUTO

NOTES: 1. SOLID SYMBOLS DENOTE TRIM
2. CMRB/HUB SPRING CONFIGURATION
3. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

FIGURE E-44

STATIC LATERAL-DIRECTIONAL STABILITY

UH-1H USA S/N 66-16088

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)	AIRCRAFT CONFIGURATION
○	8548	142.9(AFT)	0.1 LT	6700	1.0	324	56	CLEAN, NO STORES
●	8408	142.2(AFT)	0.1 LT	6000	0.5	324	105	CLEAN, NO STORES

NOTES: 1. TRIM FLIGHT CONDITION: LEVEL
2. SHADED SYMBOLS DENOTE TRIM
3. COLLECTIVE CONTROL HELD FIXED
4. HUB SPRING ENGAGEMENT OCCURS AT 45K M/R FLAPPING
5. BROKEN LINES DENOTE TEST ENVELOPE

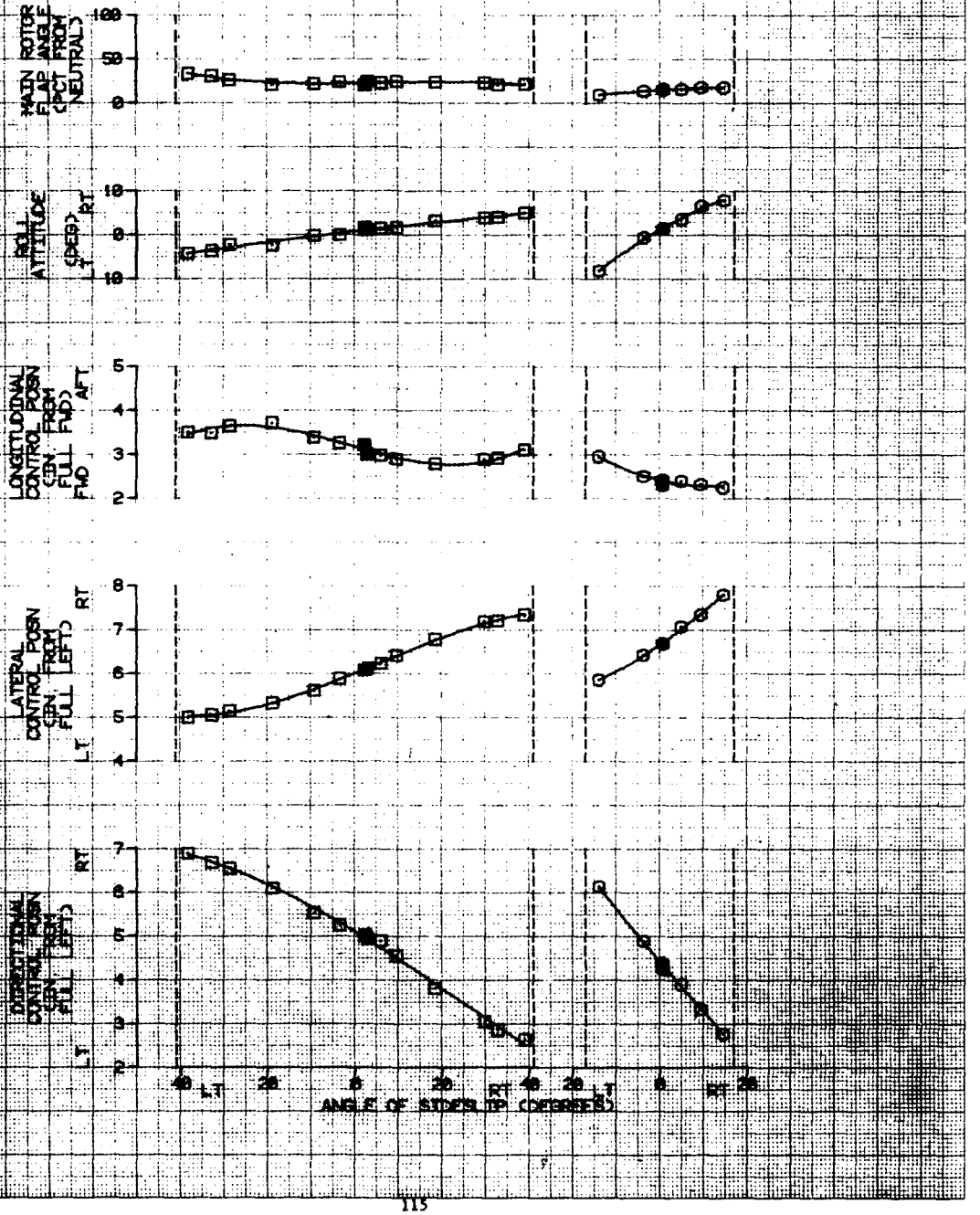


FIGURE E-45

STATIC LATERAL-DIRECTIONAL STABILITY

UH-1H USA S/N 68-16358

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)	AIRCRAFT CONFIGURATION
□	8140	141.3(AFT)	0.1LT	5920	0.5	314	54	CH58A4UB SPRING
■	8680	142.6(AFT)	0.1LT	6020	-2.5	315	103	CH58A4UB SPRING

NOTES: 1. TRIM FLIGHT CONDITION: LEVEL
2. SHADED SYMBOLS DENOTE TRIM
3. COLLECTIVE CONTROL HELD FIXED
4. HUB SPRING ENGAGEMENT OCCURS AT 45K M/R FLAPPING
5. BROKEN LINES DENOTE TEST ENVELOPE

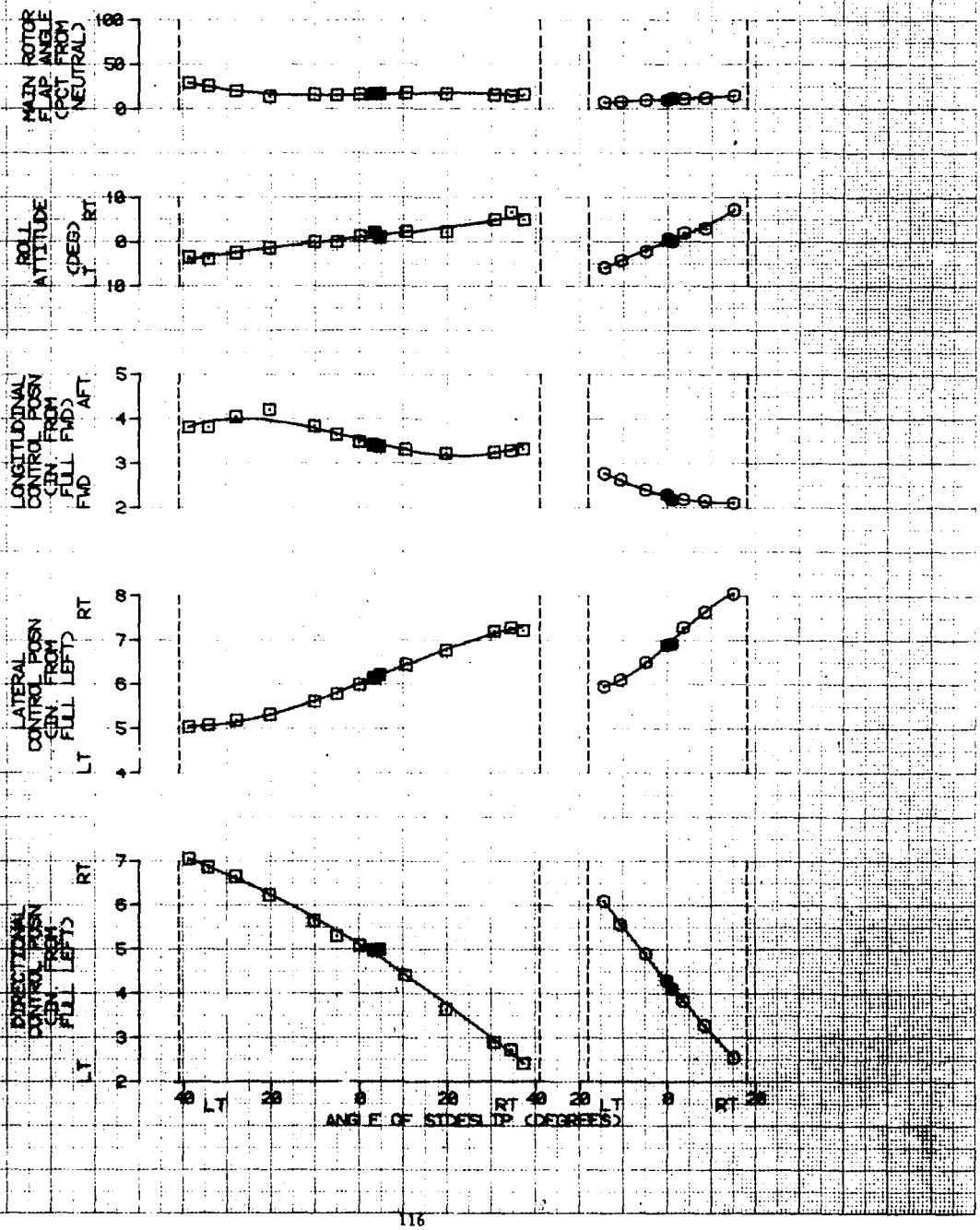


FIGURE 3-46
MANEUVERING STABILITY
UH-1H USA S/N 66-16558

SYM	AVG GROSS WEIGHT (LBS)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	TRIM CALIBRATED AIRSPEED (KTS)
△,▲	8680	131.8(FWD)	0.0	6300	11.0	325	LEVEL	76
▽,▼	8430	132.6(FWD)	0.0	5030	4.5	325	LEVEL	97

NOTES: 1. OPEN SYMBOLS DENOTE LEFT TURN
CROSSED SYMBOLS DENOTE RIGHT TURN
△,▽ SYMBOLS DENOTE PUSHOVER MANEUVER
2. SHADED SYMBOLS DENOTE TRIM
3. CMRB/HUB SPRING CONFIGURATION
4. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

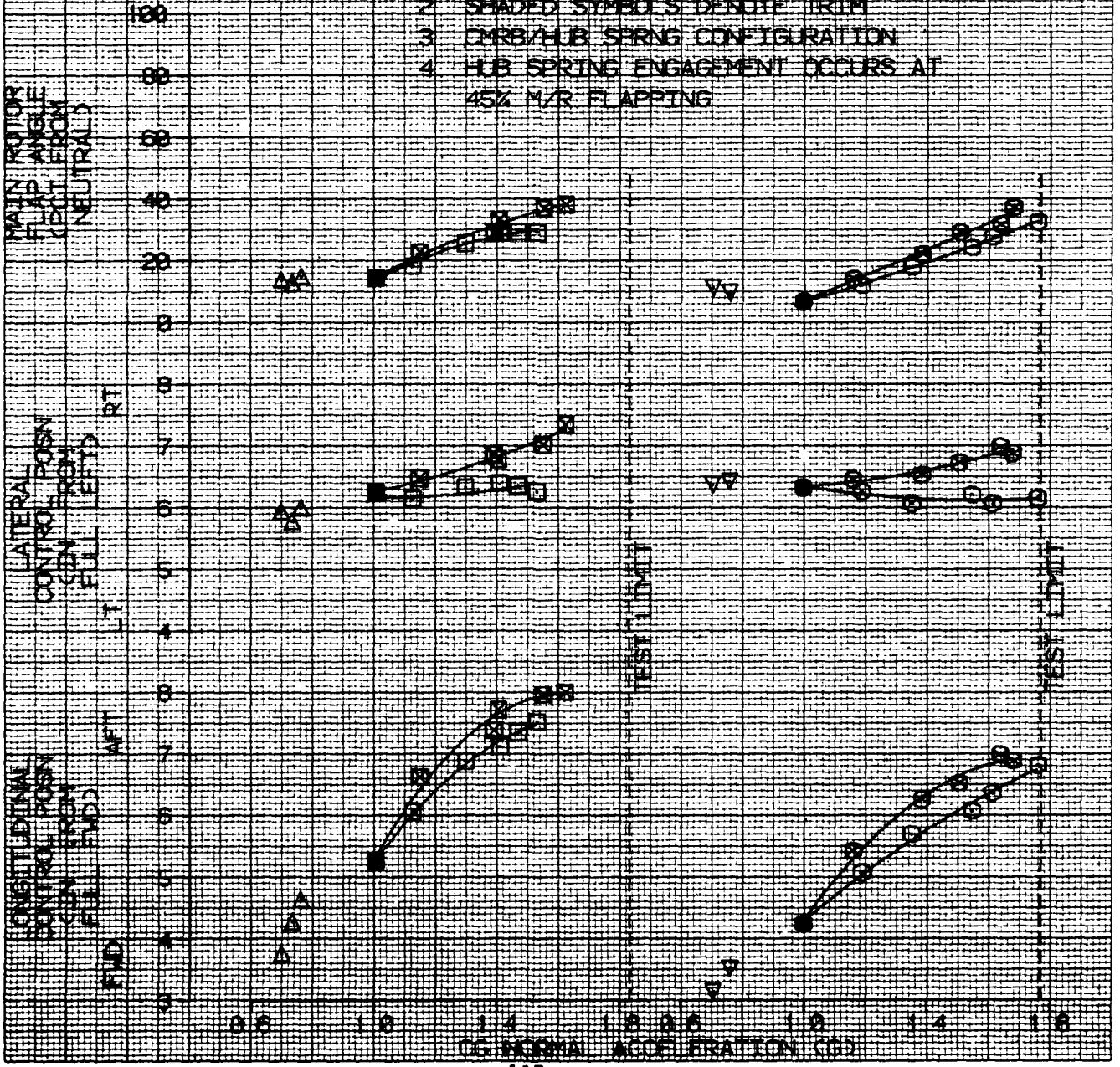


FIGURE 5-47
MANEUVERING STABILITY
UH-1H USA S/N 68-15582

SYM	AVG WEIGHT (LBS)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	TRIM CALIBRATED AIRSPEED (KT)
□	8200	131.6(FWD)	0.0	5000	11.0	315	LEVEL	77
○	8600	133.2(FWD)	0.0	6000	11.0	314	LEVEL	97

NOTES: 1. OPEN SYMBOLS DENOTE LEFT TURN
CROSSED SYMBOLS DENOTE RIGHT TURN
2. SHADED SYMBOLS DENOTE TRIM
3. CHRB/HUB SPRING CONFIGURATION
4. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

INSTM FAILED DURING TEST

TEST LIMIT

TEST LIMIT

CG NORMAL ACCELERATION (G)

FIGURE E-48

MANEUVERING START TTY

UH-1H USA S/N 66-16528

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TORQUE CONDITION	TRIM AIRSPEED (KTS)
◆	8448	142 (AFT)	0.0	6190	15.0	316	LEVEL	98
▼	8260	141 (AFT)	0.0	6000	16.0	314	LEVEL	96

NOTES: 1. CROSSED SYMBOLS DENOTE RIGHT TURN
▽ SYMBOLS DENOTE PUSHOVER MANEUVER
2. SHADED SYMBOLS DENOTE TRIM
3. CHRB/HUB SPRING CONFIGURATION
4. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

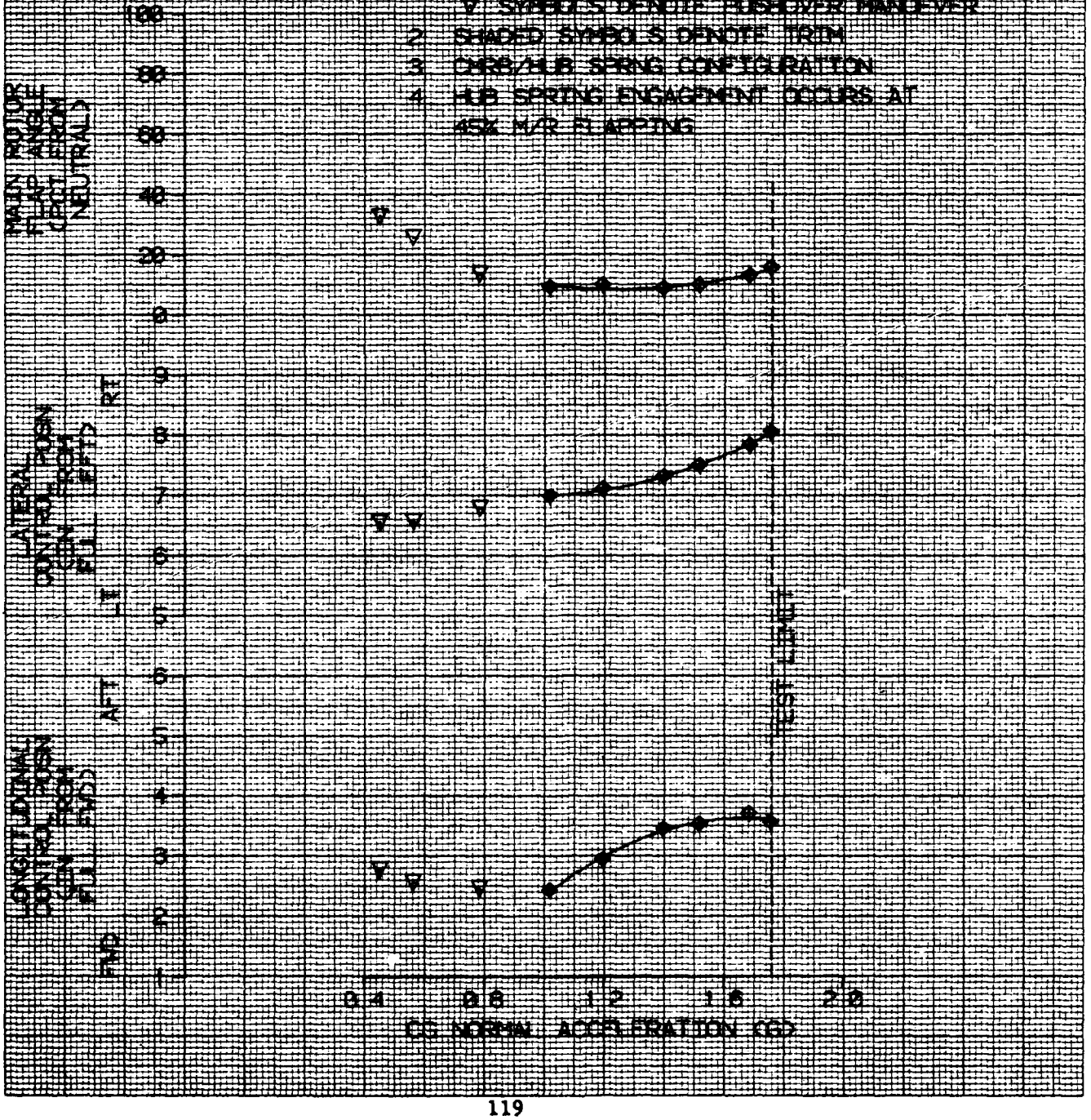


FIGURE E-19A

WIND-UP TURN

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)
8630	137 4	0 0	7540	-1 5	314	98

NOTES: 1. CMRB/HUB SPRNG CONFIGURATION
2. LIMIT LOAD FACTOR = 1 65
3. NEVER EXCEED AIRSPEED = 100 KCAS

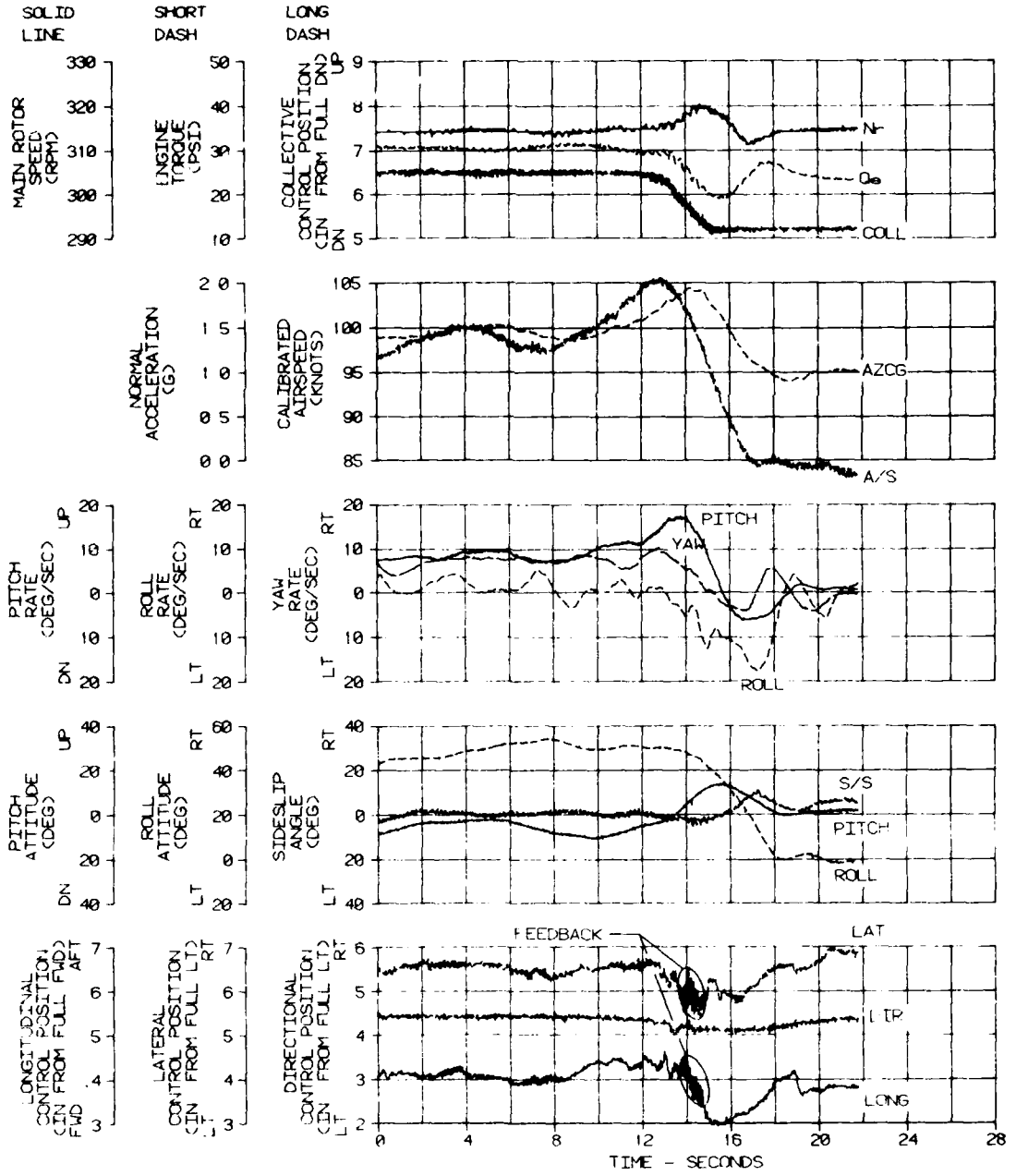


FIGURE E-49B

WIND-UP TURN

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)
8630	137.4	0 0	7540	-1 5	314	98

NOTES: 1 CMRB/HUB SPRNG CONFIGURATION
2 HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

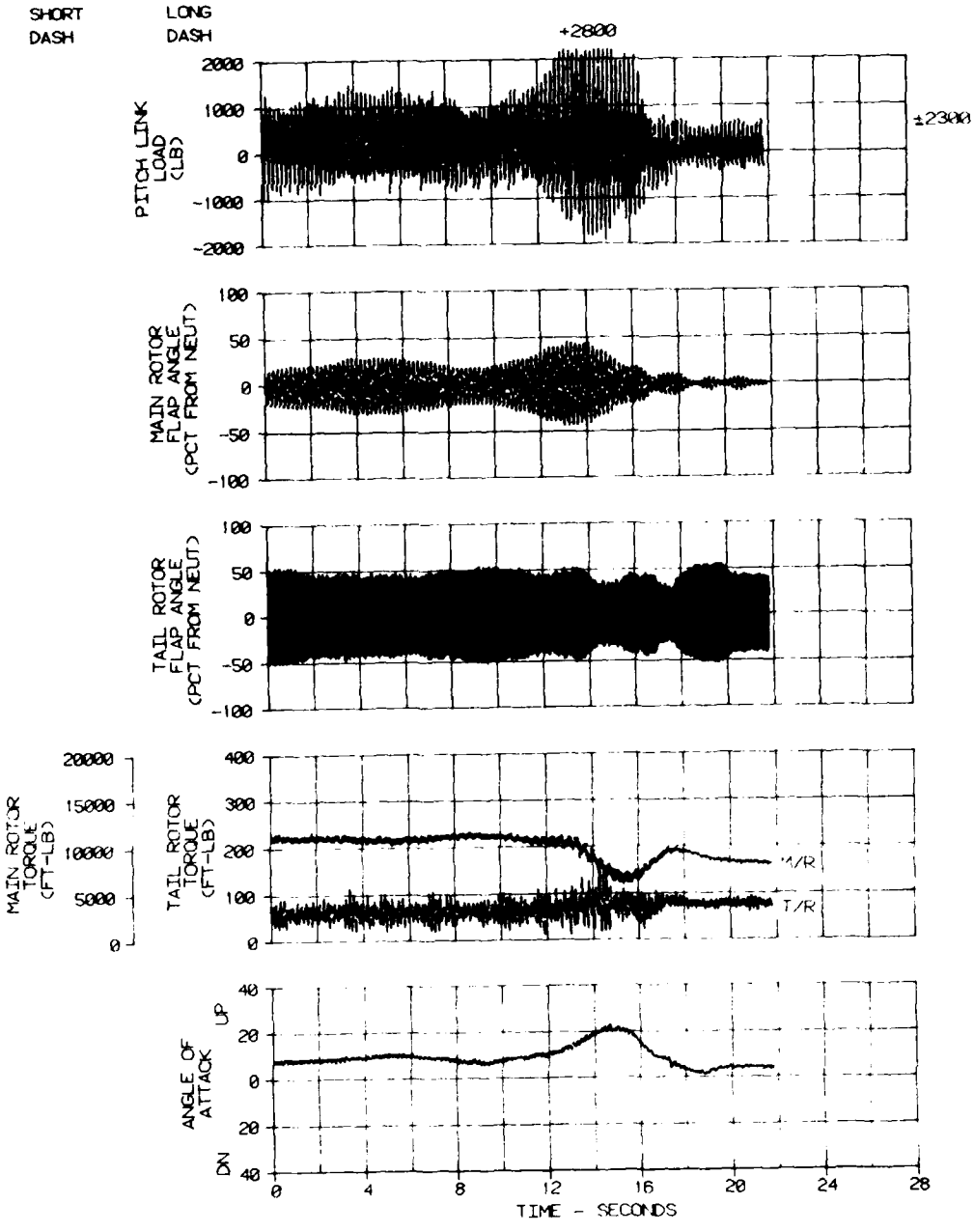


FIGURE 5-60
MANEUVERING ENVELOPE
UH-1H USA S/N 68-16582
ONSET OF CONTROL FEEDBACK

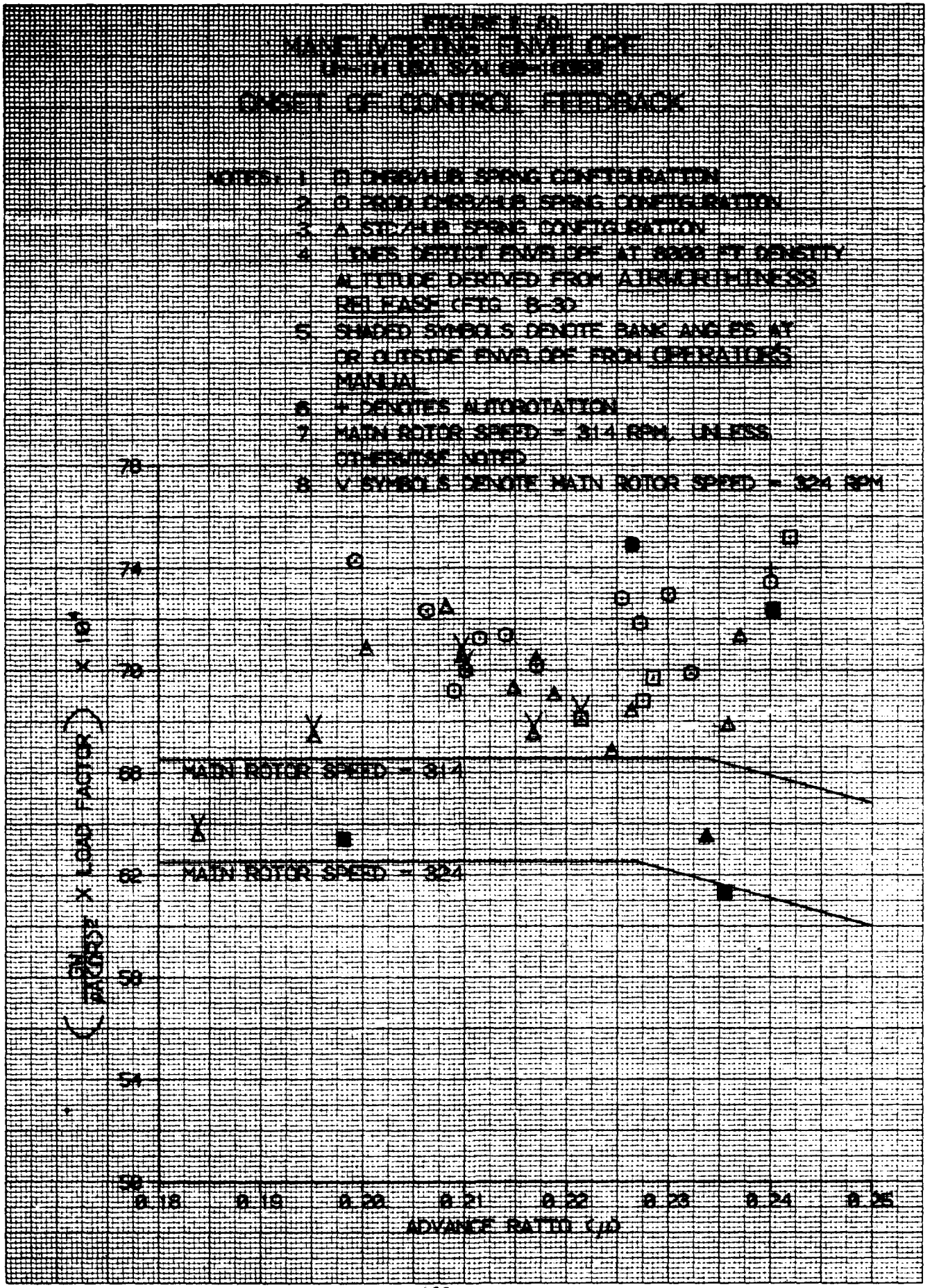


FIGURE E-51A

WIND-UP TURN

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)
8540	137.3	0.0	8290	23.5	313	96

NOTES: 1. PROD CMRB/HUB SPRNG CONFIGURATION
2. LIMIT LOAD FACTOR = 1.63
3. NEVER EXCEED AIRSPEED = 98 KCAS

SOLID LINE — SHORT DASH — LONG DASH

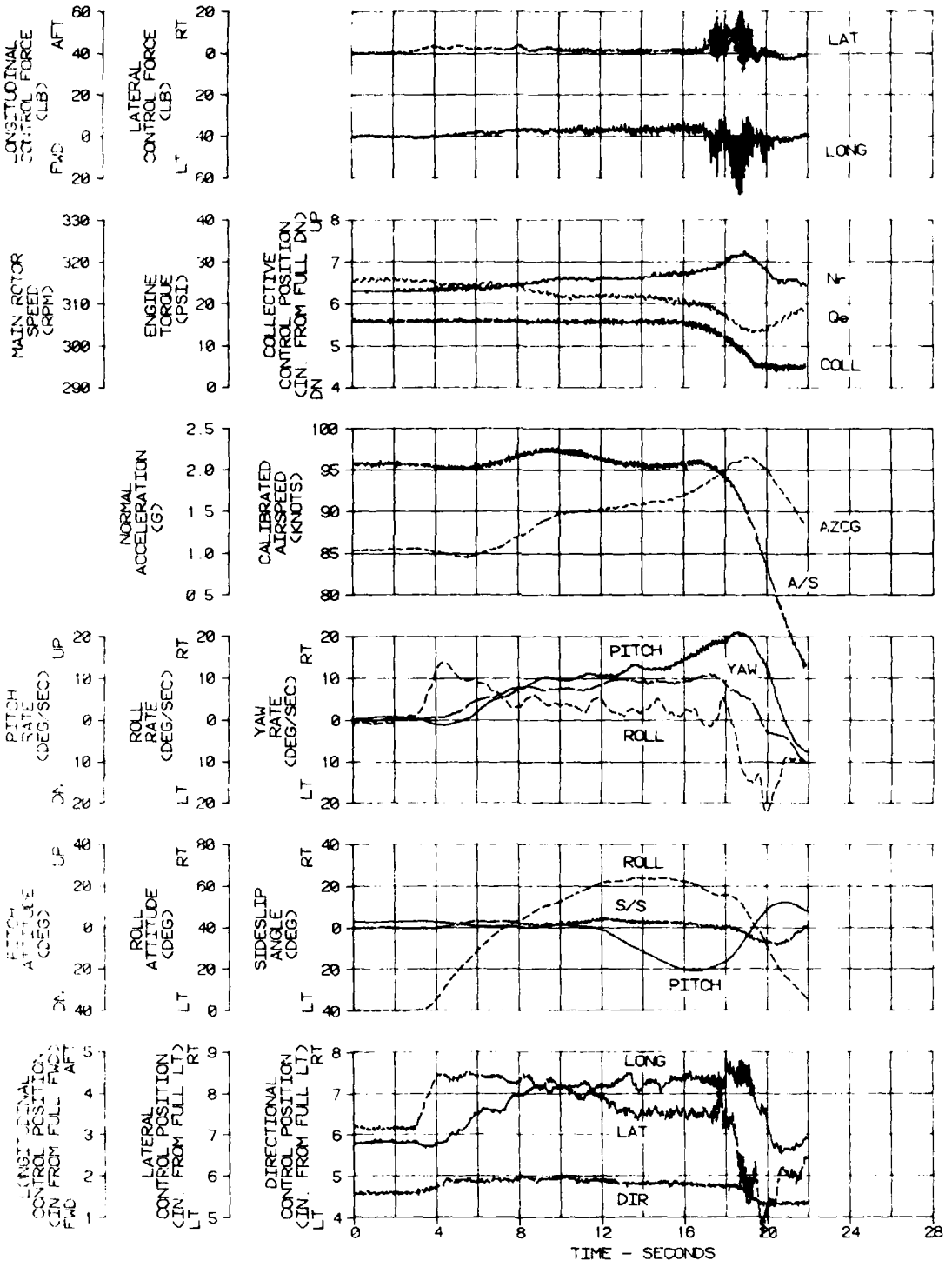


FIGURE E-51B

WIND-UP TURN

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)
8540	137.3	0.0	8290	23.5	313	96

NOTES: 1. PROD CMRB/HUB SPRNG CONFIGURATION
2. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

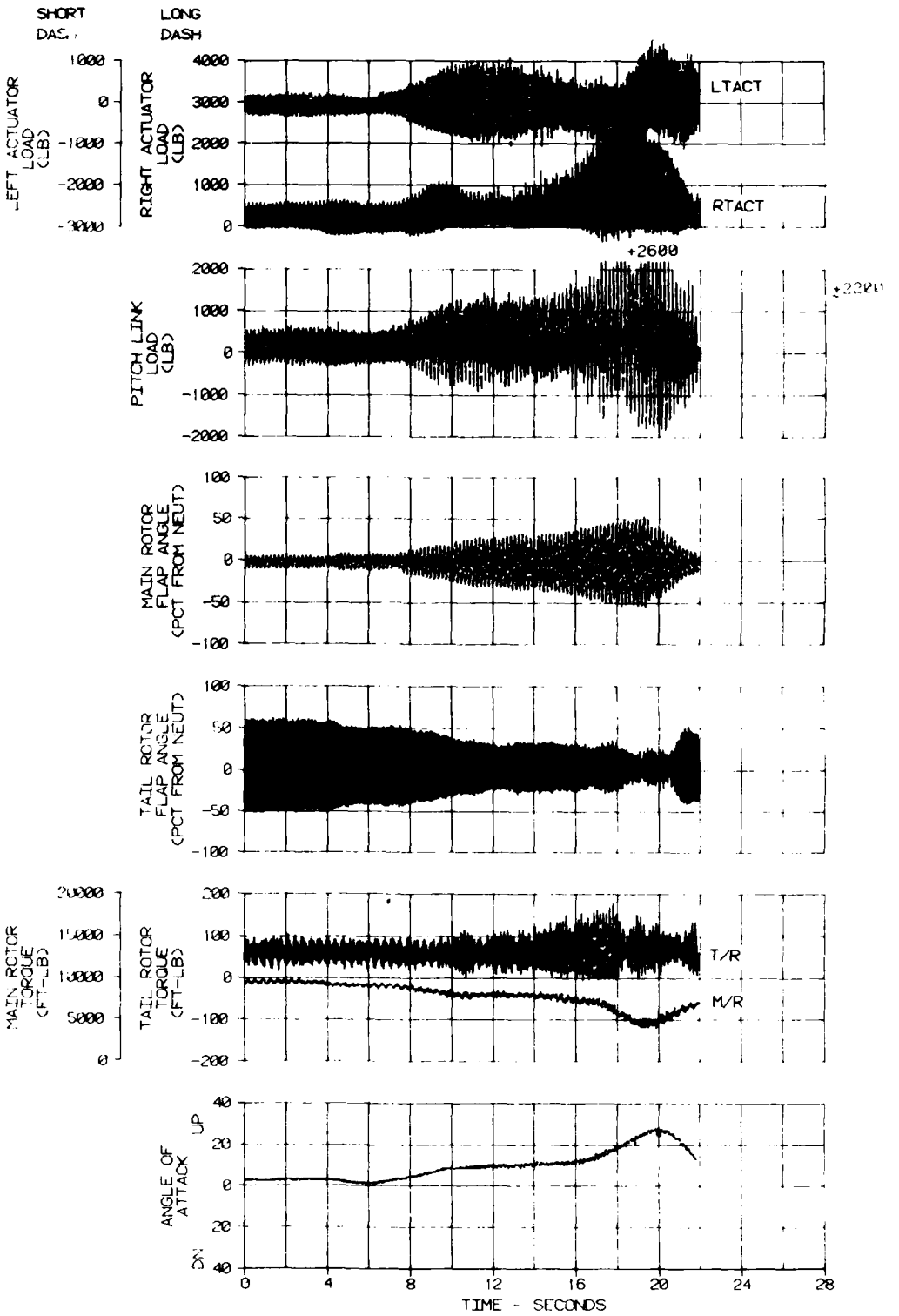


FIGURE E-52A

WIND-UP TURN

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)
8540	137.3	0.0	7480	19.5	315	87

NOTES: 1. STD/HUB SPRNG CONFIGURATION
2. LIMIT LOAD FACTOR = 1.67
3. NEVER EXCEED AIRSPEED = 100 KCAS

SOLID LINE — SHORT DASH — LONG DASH

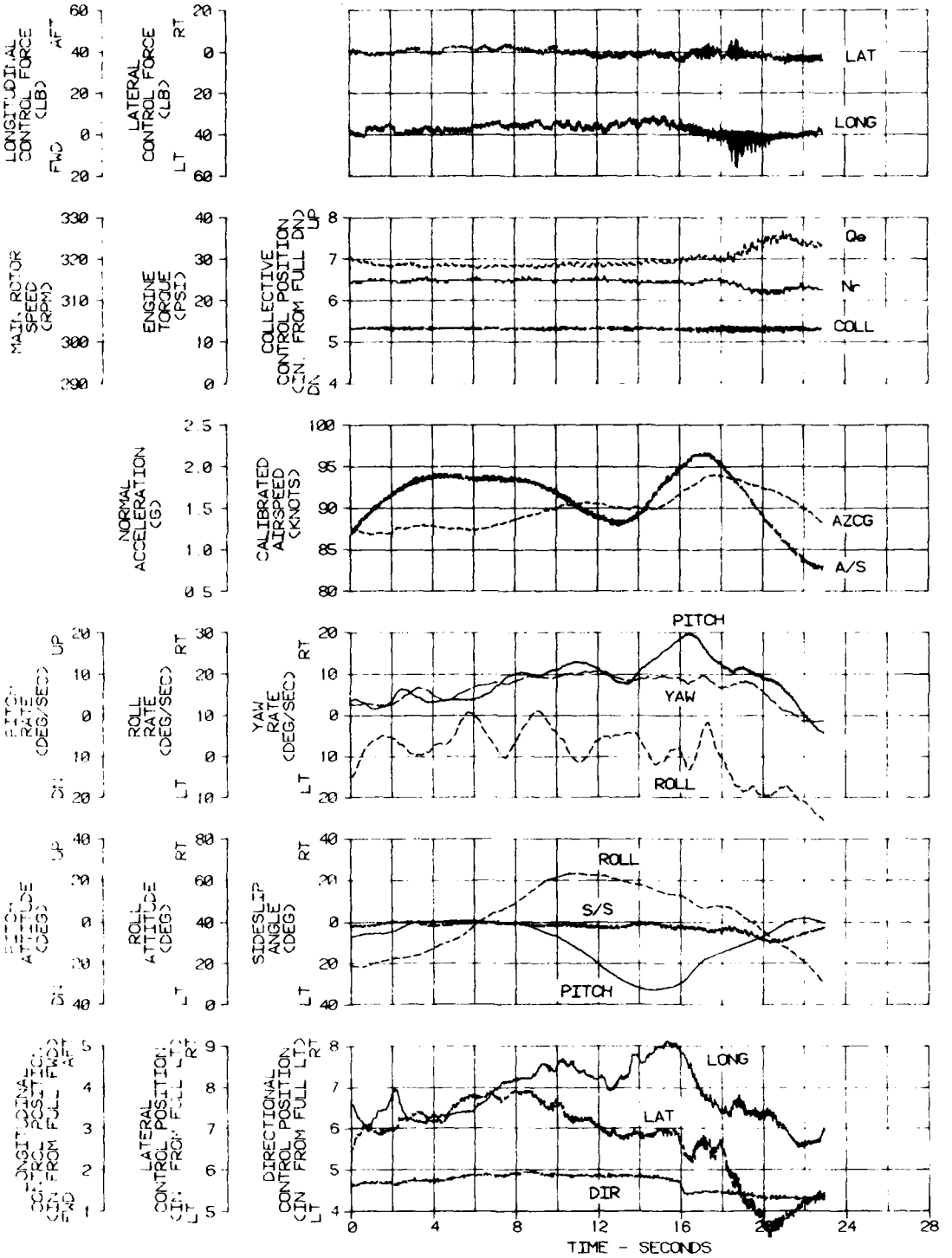


FIGURE E-52B

WIND-UP TURN

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)
8540	137 3	0 0	7480	19 5	315	87

NOTES 1. STD/HUB SPRNG CONFIGURATION
2. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

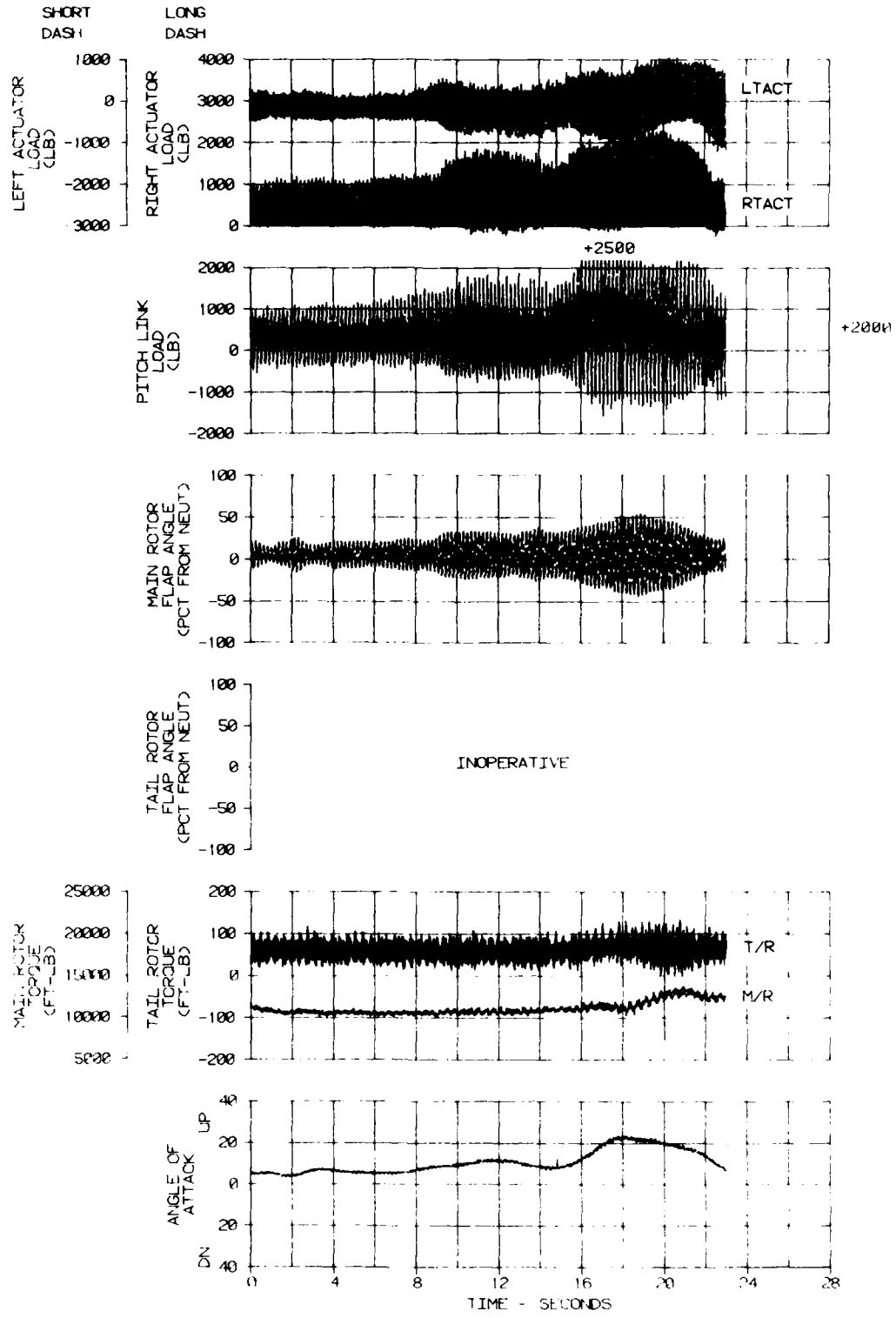


FIGURE E-53A

180 DEG TURN TO AN AUTOROTATIONAL LANDING

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	INITIAL DENSITY ALTITUDE (FEET)	OAT (DEG C)	INITIAL ROTOR SPEED (RPM)	INITIAL CALIBRATED AIRSPEED (KT)
7320	138 9	0.0	3830	14 0	323	92

NOTES 1. CMRB/HUB SPRNG CONFIGURATION
2 LIMIT LOAD FACTOR = 2 17

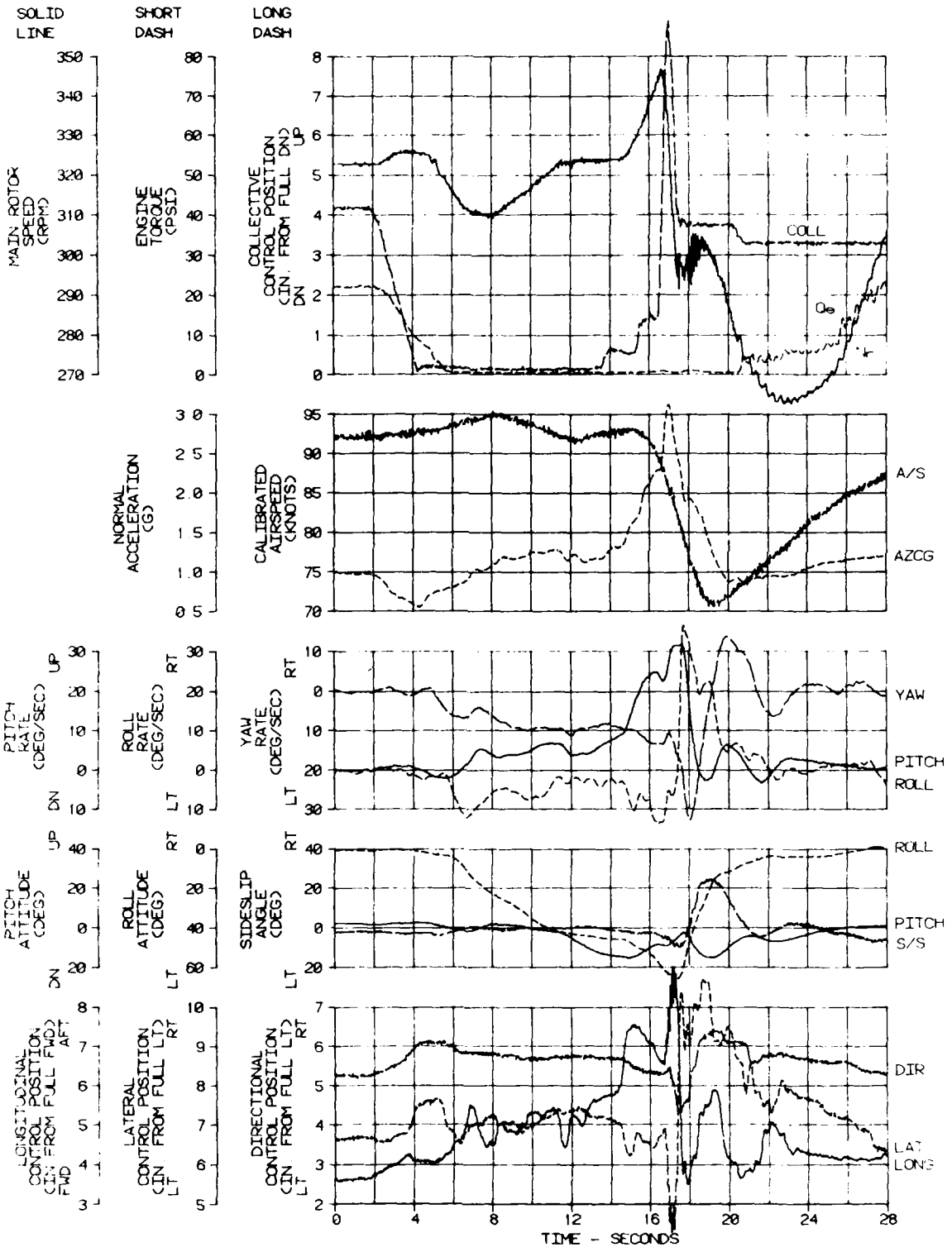


FIGURE E-53B

180 DEG TURN TO AN AUTOROTATIONAL LANDING

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	INITIAL DENSITY ALTITUDE (FEET)	OAT (DEG C)	INITIAL ROTOR SPEED (RPM)	INITIAL CALIBRATED AIRSPEED (KT)
7320	138.9	0.0	3830	14.0	323	92

NOTES: 1. CMRB/HUB SPRNG CONFIGURATION
2. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

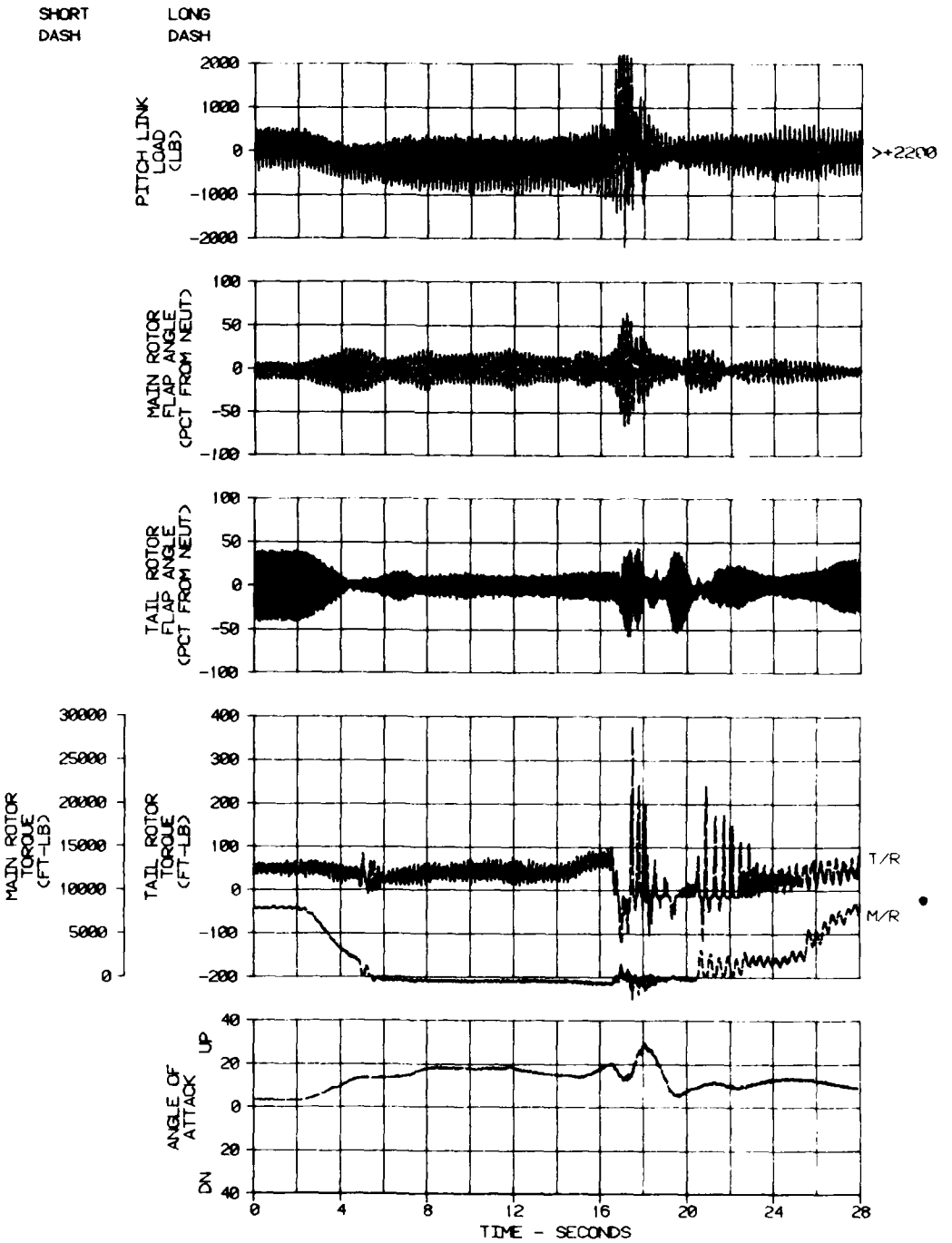


FIGURE E-54A

WIND-UP TURN DURING AN AUTOROTATIONAL DESCENT

UH-1H USA S/N 68-16358

GROSS WEIGHT	CG LOCATION LONG	CG LOCATION LAT	TRIM DENSITY ALTITUDE	OAT	TRIM ROTOR SPEED	TRIM CALIBRATED AIRSPEED
(LB)	(FS)	(BL)	(FEET)	(DEG C)	(RPM)	(KT)
8410	139.9	0.0	8070	20.0	309	94

NOTES: 1. PROD CMRB/HUB SPRNG CONFIGURATION
2. LIMIT LOAD FACTOR = 1.66
3. NEVER EXCEED AIRSPEED = 99 KCAS

SOLID LINE — SHORT DASH — LONG DASH

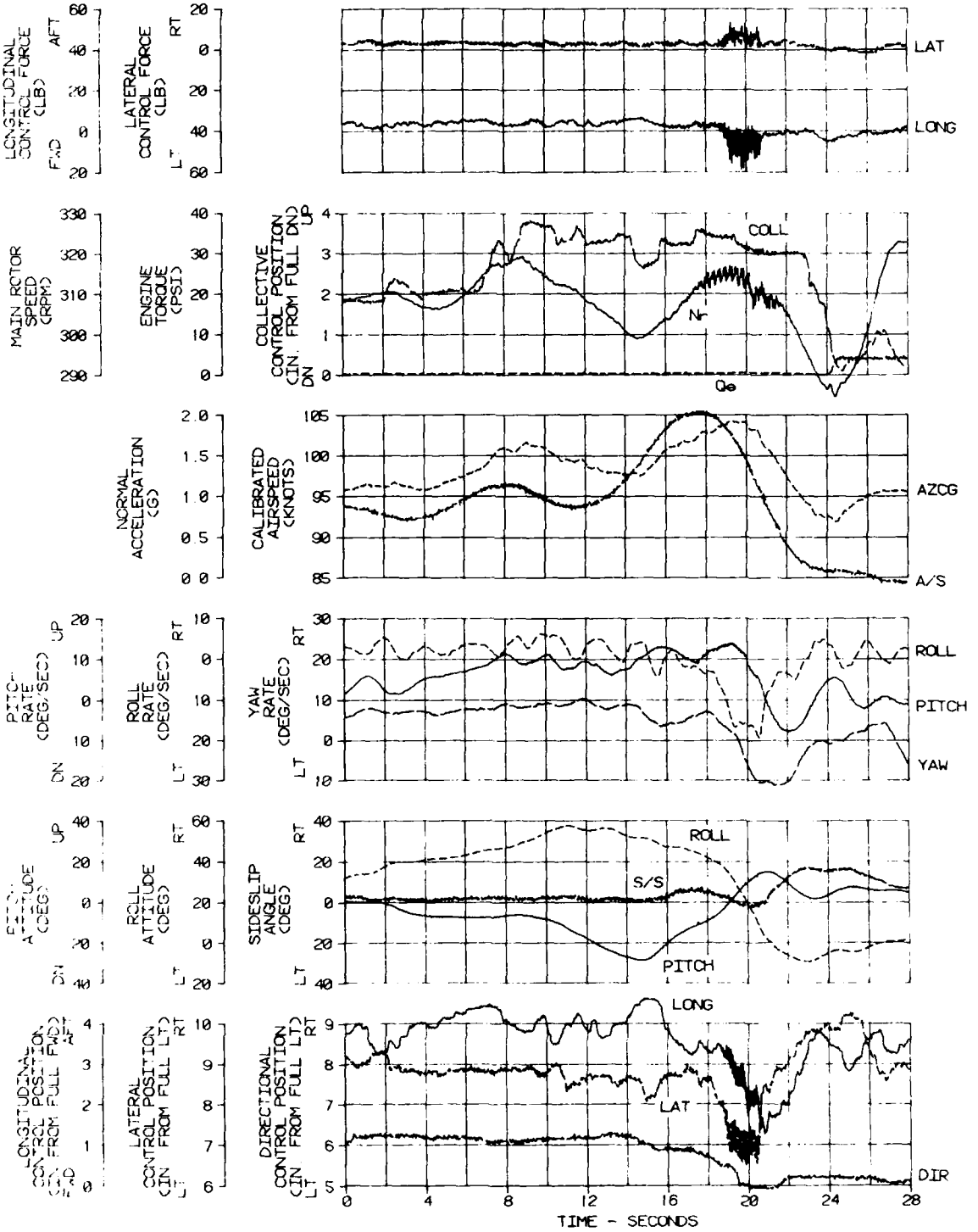


FIGURE E-54B

WIND-UP TURN DURING AN AUTOROTATIONAL DESCENT

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)
8410	139.9	0.0	8070	20 0	309	94

NOTES: 1. PROD CMRB/HUB SPRNG CONFIGURATION
2. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

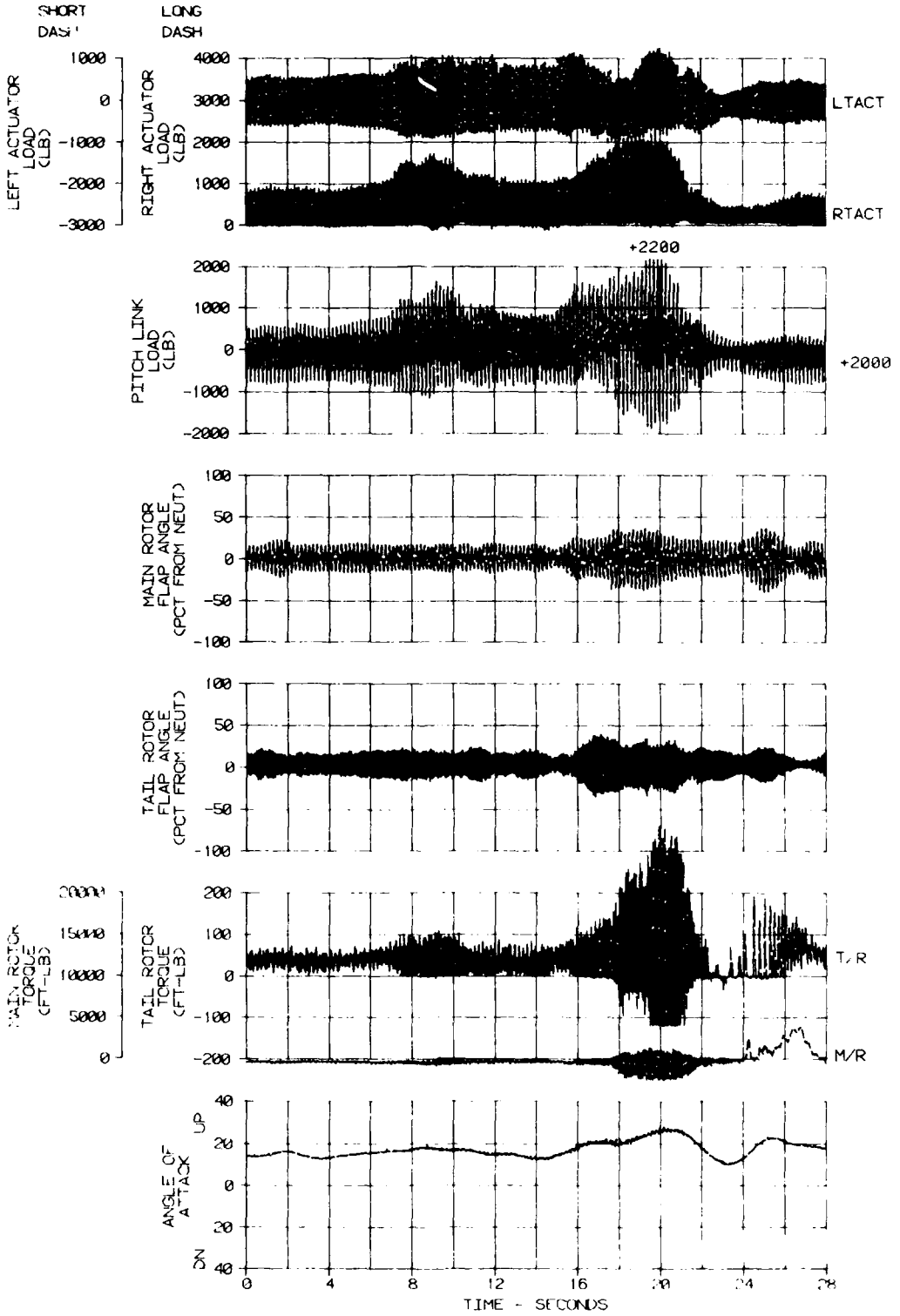


FIGURE E-55A

WIND-UP TURN DURING AN AUTOROTATIONAL DESCENT

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)
8210	139.3	0.0	8200	18.0	315	93

NOTES: 1. STD/HUB SPRNG CONFIGURATION
2. LIMIT LOAD FACTOR = 1.70
3. NEVER EXCEED AIRSPEED = 100 KCAS

SOLID LINE — SHORT DASH — LONG DASH

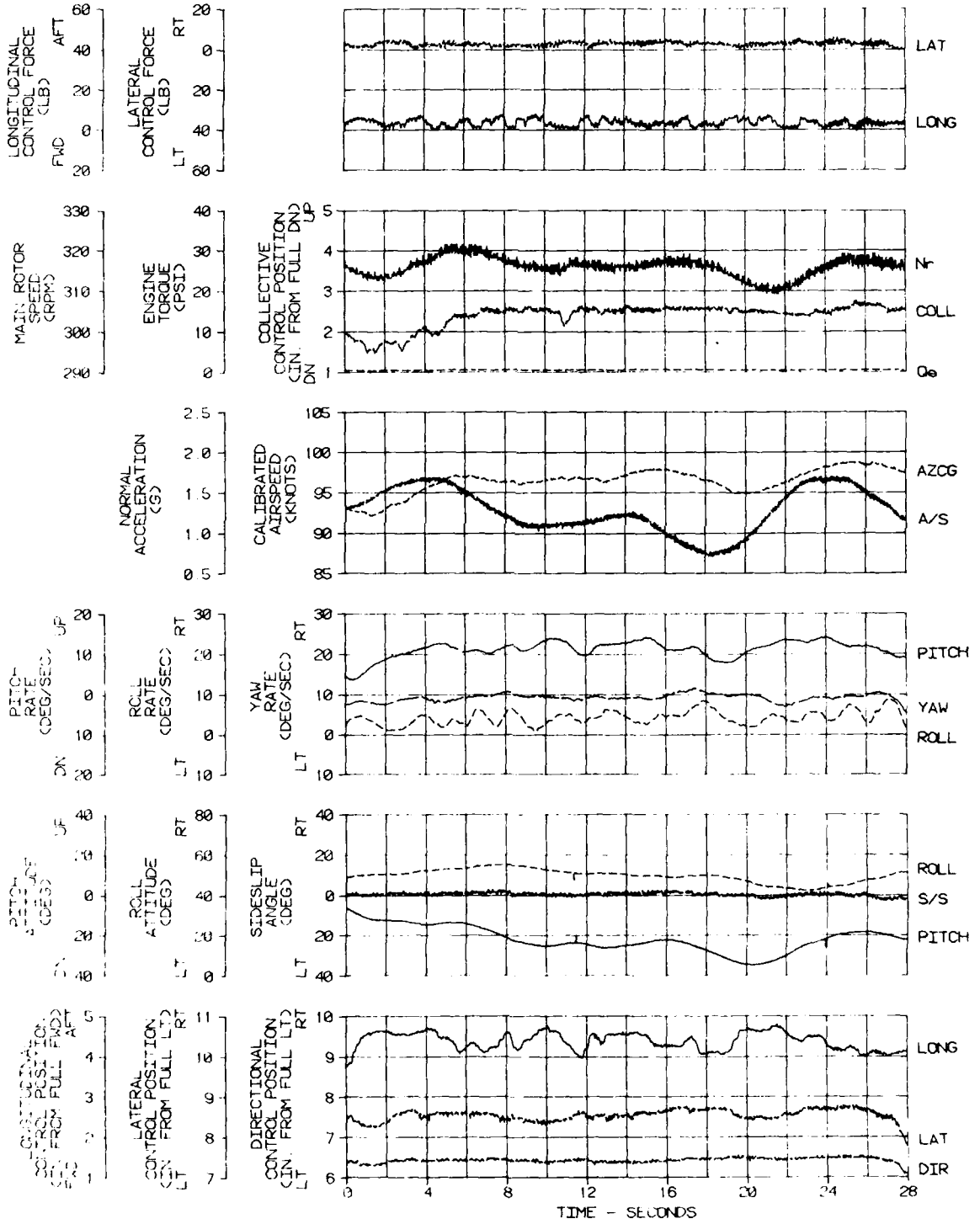


FIGURE E-55B

WIND-UP TURN DURING AN AUTOROTATIONAL DESCENT

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)
8210	139.3	0.0	8200	18 0	315	93

NOTES: 1. STD/HUB SPRNG CONFIGURATION
2. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

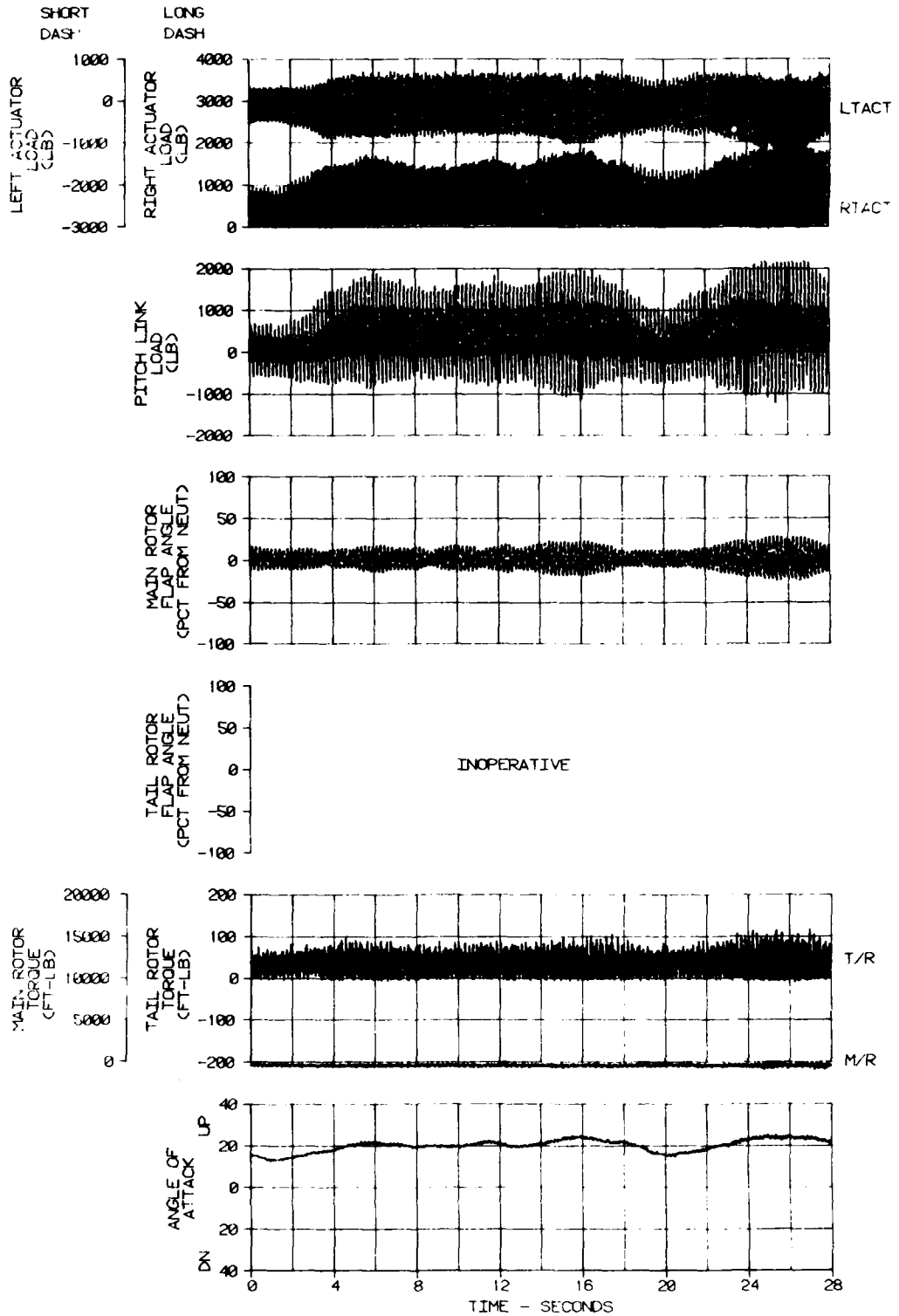


FIGURE E-56A

ROLL REVERSAL

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM ROTOR SPEED (RPM)
8223	131.6(FWD)	0.0	6300	9 0	96	314

NOTES: 1. CMRB/HUB SPRNG CONFIGURATION
2. COLLECTIVE CONTROL HELD FIXED THROUGHOUT MANEUVER

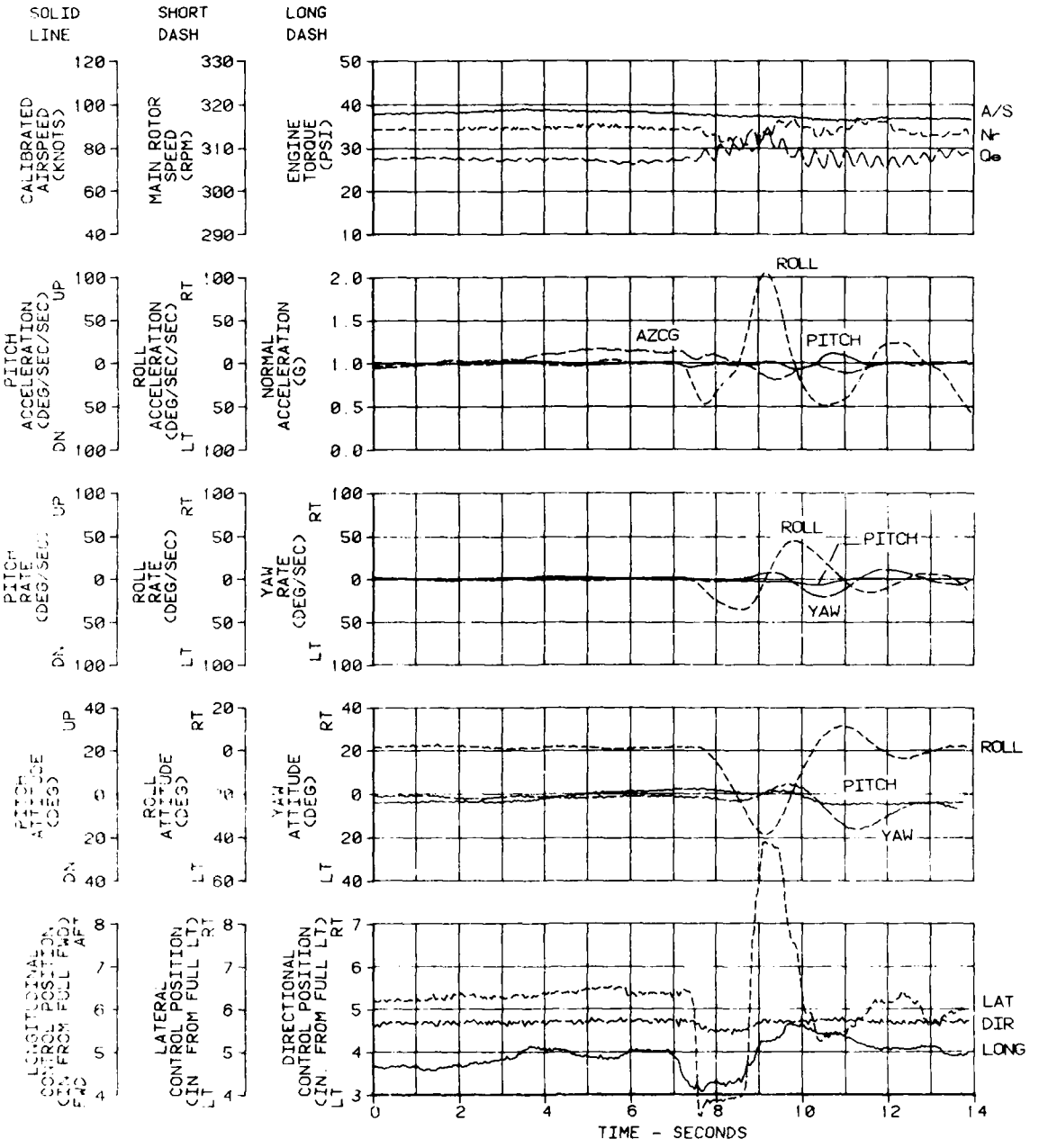


FIGURE E-56B

ROLL REVERSAL

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM ROTOR SPEED (RPM)
8220	131.6(FWD)	0.0	6300	9 0	96	314

NOTES: 1. CMRB/HUB SPRNG CONFIGURATION
2. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING
3. COLLECTIVE CONTROL HELD FIXED THROUGHOUT MANEUVER

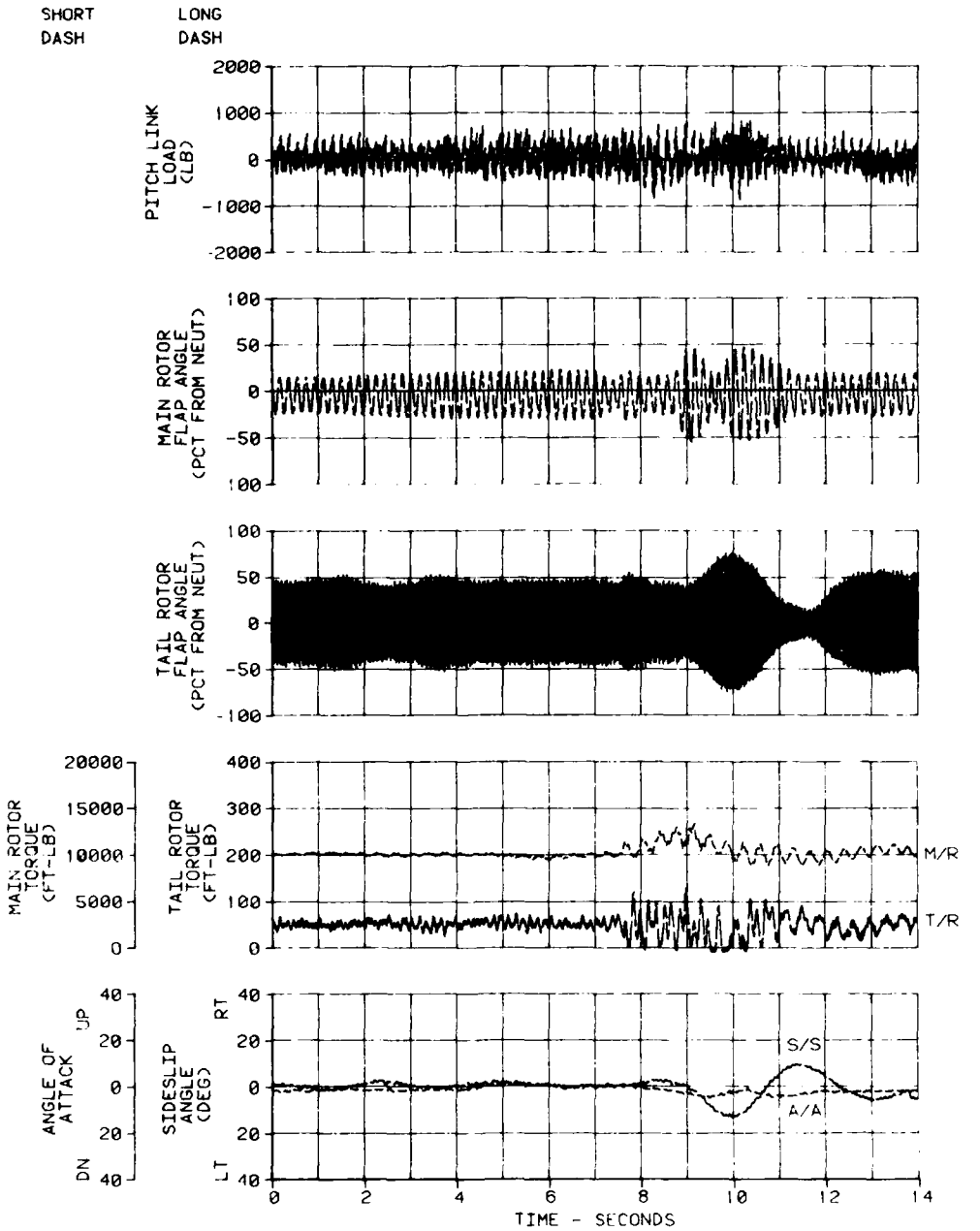


FIGURE E-57A

ROLL REVERSAL

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM ROTOR SPEED (RPM)
8290	131.9(FWD)	0.0	6190	9.5	95	315

NOTES: 1. CMRB/HUB SPRNG CONFIGURATION
2. COLLECTIVE CONTROL HELD FIXED THROUGHOUT MANEUVER

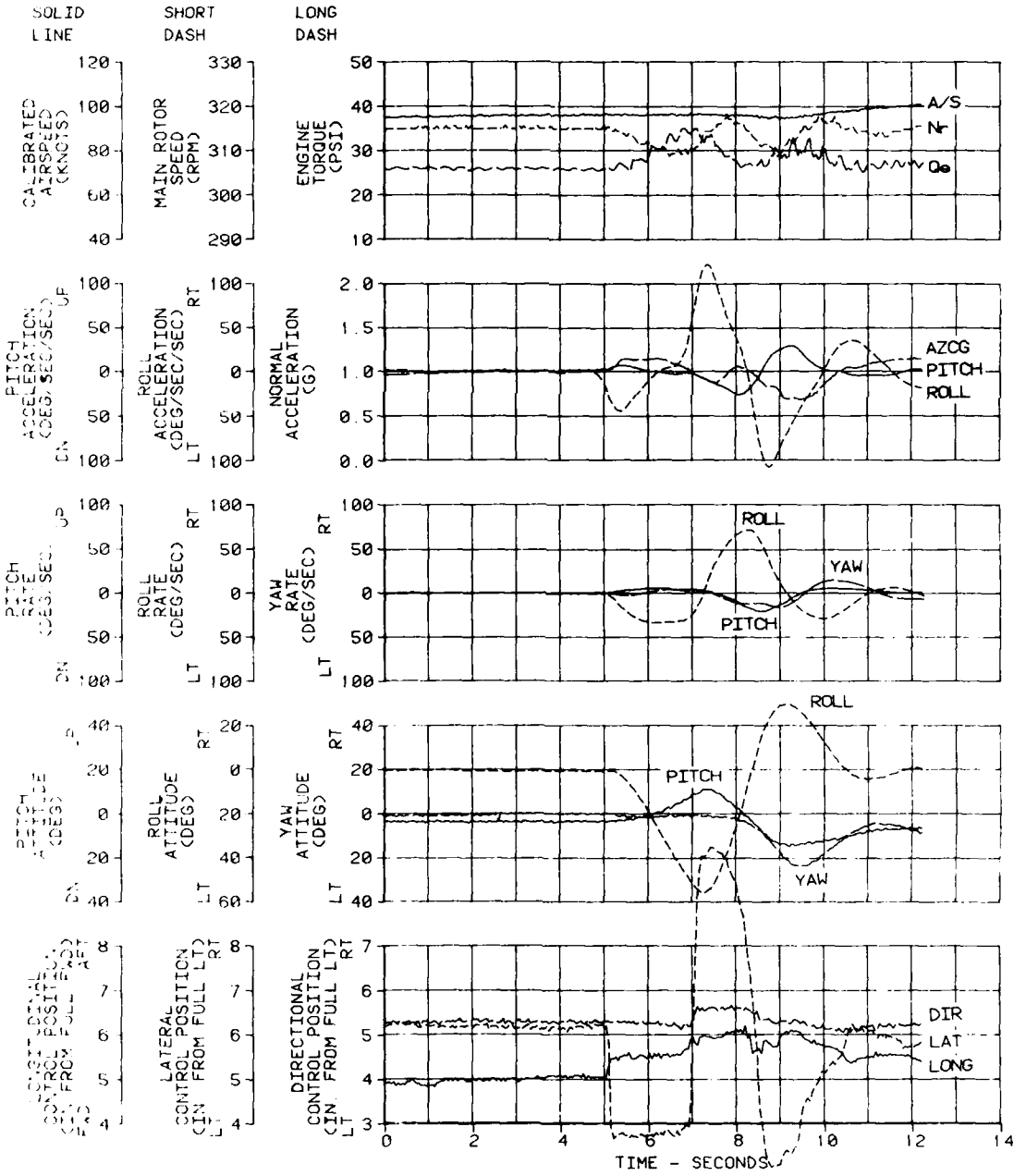


FIGURE E-57B

ROLL REVERSAL

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM ROTOR SPEED (RPM)
8290	131.9(FWD)	0.0	6190	9.5	95	315

NOTES: 1. CMRB/HUB SPRNG CONFIGURATION
2. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING
3. COLLECTIVE CONTROL HELD FIXED THROUGHOUT MANEUVER

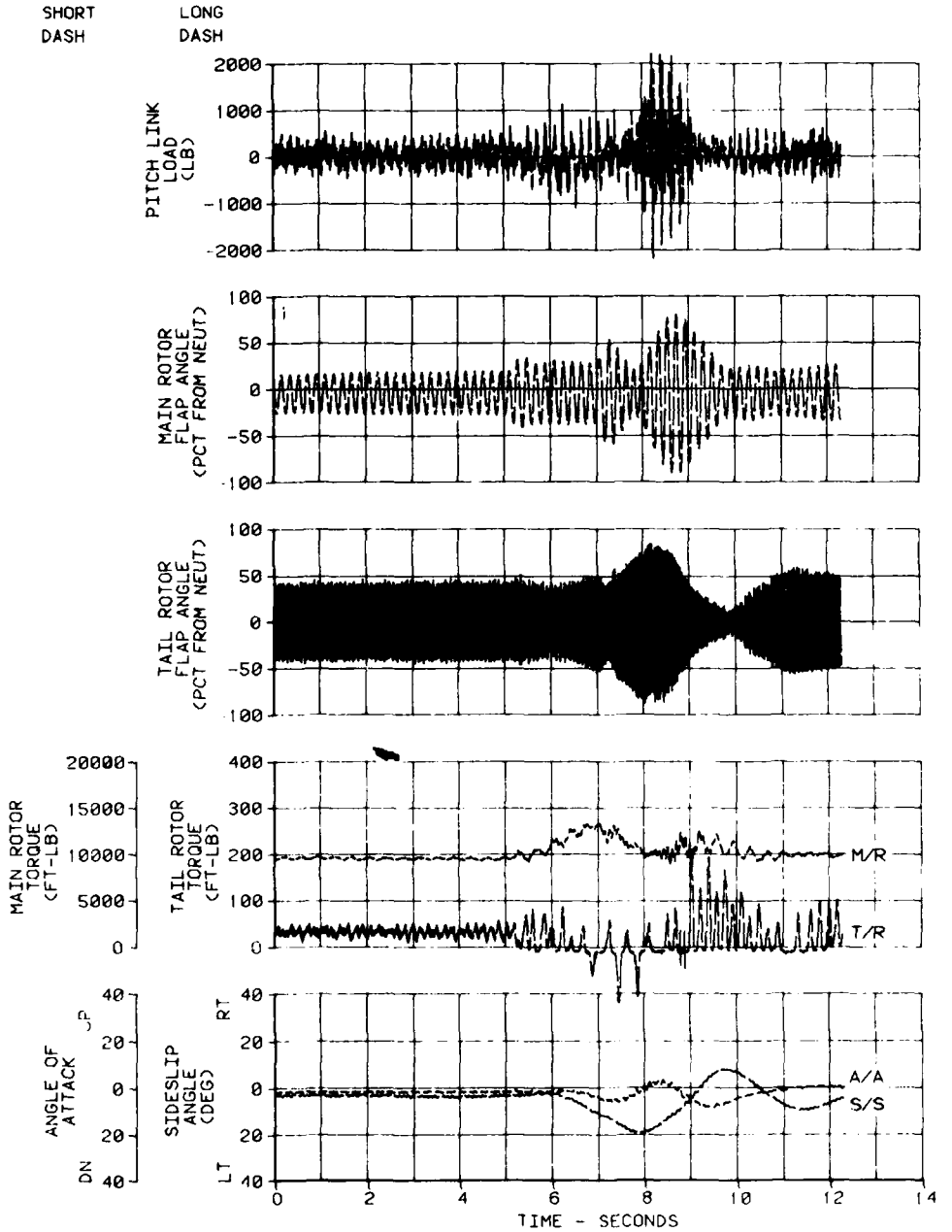


FIGURE B-56

ROLL REVERSALS

UH-1H USA SN 66-16566

AVG GROSS WEIGHT (LBS)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALTITUDE (FT)
8400	132.5 (FWD)	0.0	7000

TRIM ROTOR SPEED = 324 RPM

NOTES:
1. CMRB/HUB SPRING CONFIGURATION
2. OPEN SYMBOLS DENOTE TRIM AIRSPEED = 75 KCAS
3. SHADED SYMBOLS DENOTE TRIM AIRSPEED = 95 KCAS
4. LINES OF NORMAL ACCELERATION BASED ON MAIN ROTOR SPEEDS OF 314 AND 324 RPM

SYM	NORM ACCEL (G)	SYM	NORM ACCEL (G)
△	0.50	⋈	0.85
□	0.55	◇	0.90
⌂	0.60	▽	0.95
▽	0.65	∞	1.00
⋈	0.70	⋈	1.05
◇	0.75	⋈	1.10
△	0.80		

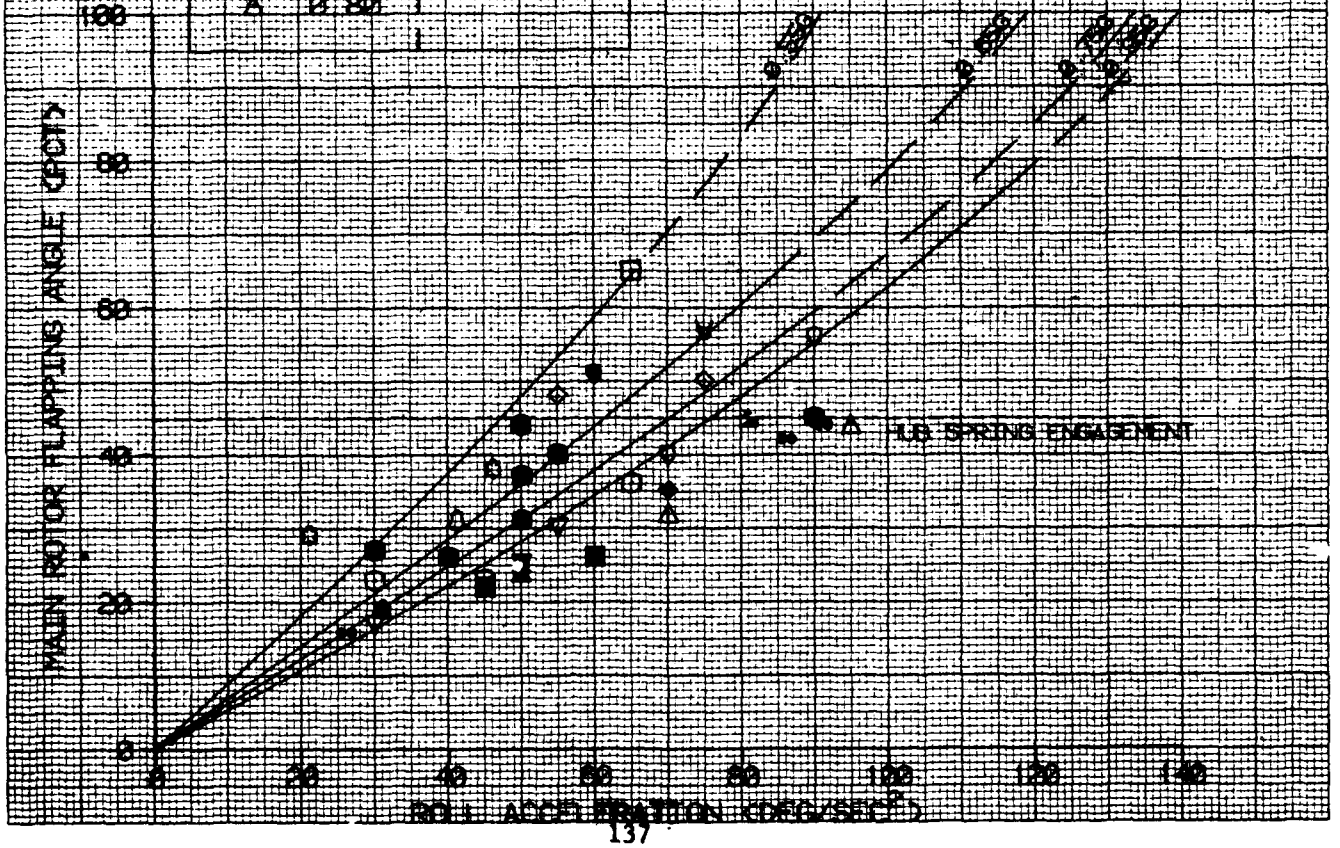


FIGURE E-59

ROLL REVERSALS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALTITUDE (FT)
8400	132.5 (FWD)	0.0	7000

TRIM ROTOR SPEED = 314 RPM

NOTES:
1. CMRB/HUB SPRNG CONFIGURATION
2. OPEN SYMBOLS DENOTE TRIM AIRSPEED = 75 KCAS
3. SHADED SYMBOLS DENOTE TRIM AIRSPEED = 95 KCAS
4. LINES OF NORMAL ACCELERATION BASED ON MAIN ROTOR SPEEDS OF 314 AND 324 RPM

SYM	NORM ACCEL (G)	SYM	NORM ACCEL (G)
△	0.50	⅓	0.85
□	0.55	◇	0.90
○	0.60	▽	0.95
◇	0.65	∞	1.00
▽	0.70	⅓	1.05
⊙	0.75	b	1.10
△	0.80		

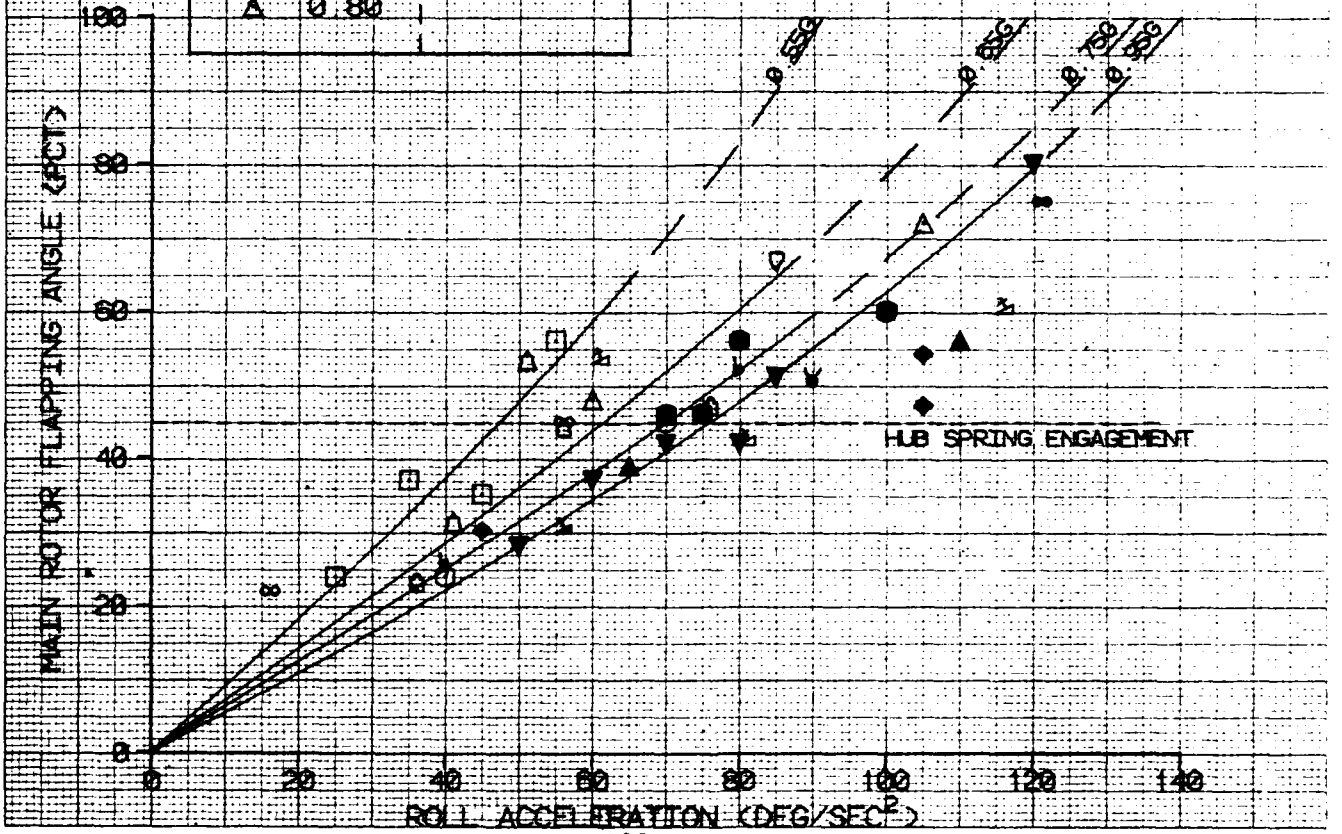


FIGURE E-60

LONGITUDINAL PULSE IN MAXIMUM POWER CLIMB

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)
8120	140.9(AFT)	0.0	6060	13.5	323	55

NOTES: 1. CMRB/HUB SPRNG CONFIGURATION
2. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

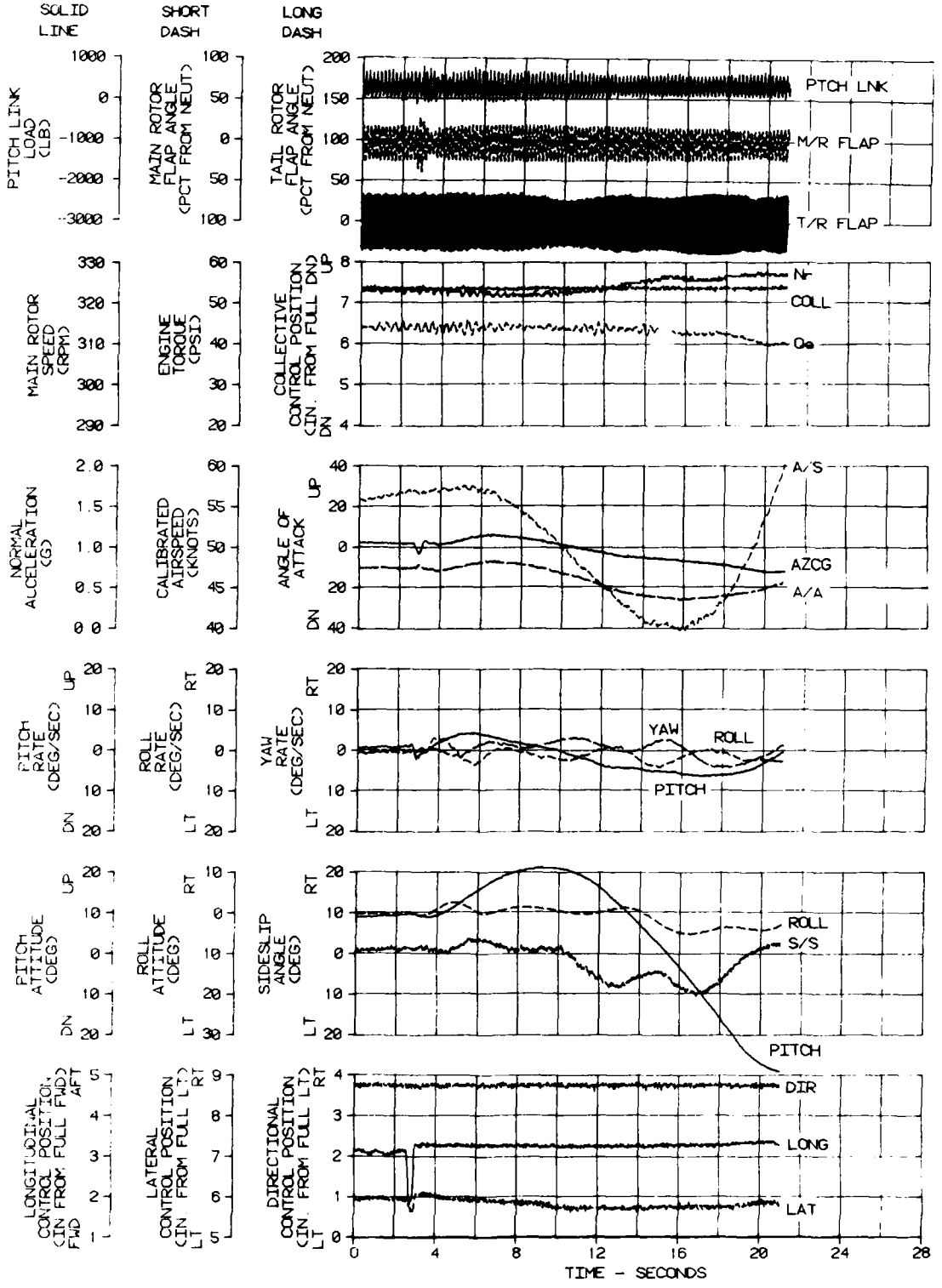


FIGURE E-6:

MAXIMUM POWER CLIMB

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)
8100	140.5(AFT)	0.0	5270	6.5	314	55

NOTES: 1. CMRB/HUB SPRING CONFIGURATION
2. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING
3. MANEUVER INITIATED AT 51 KCAS

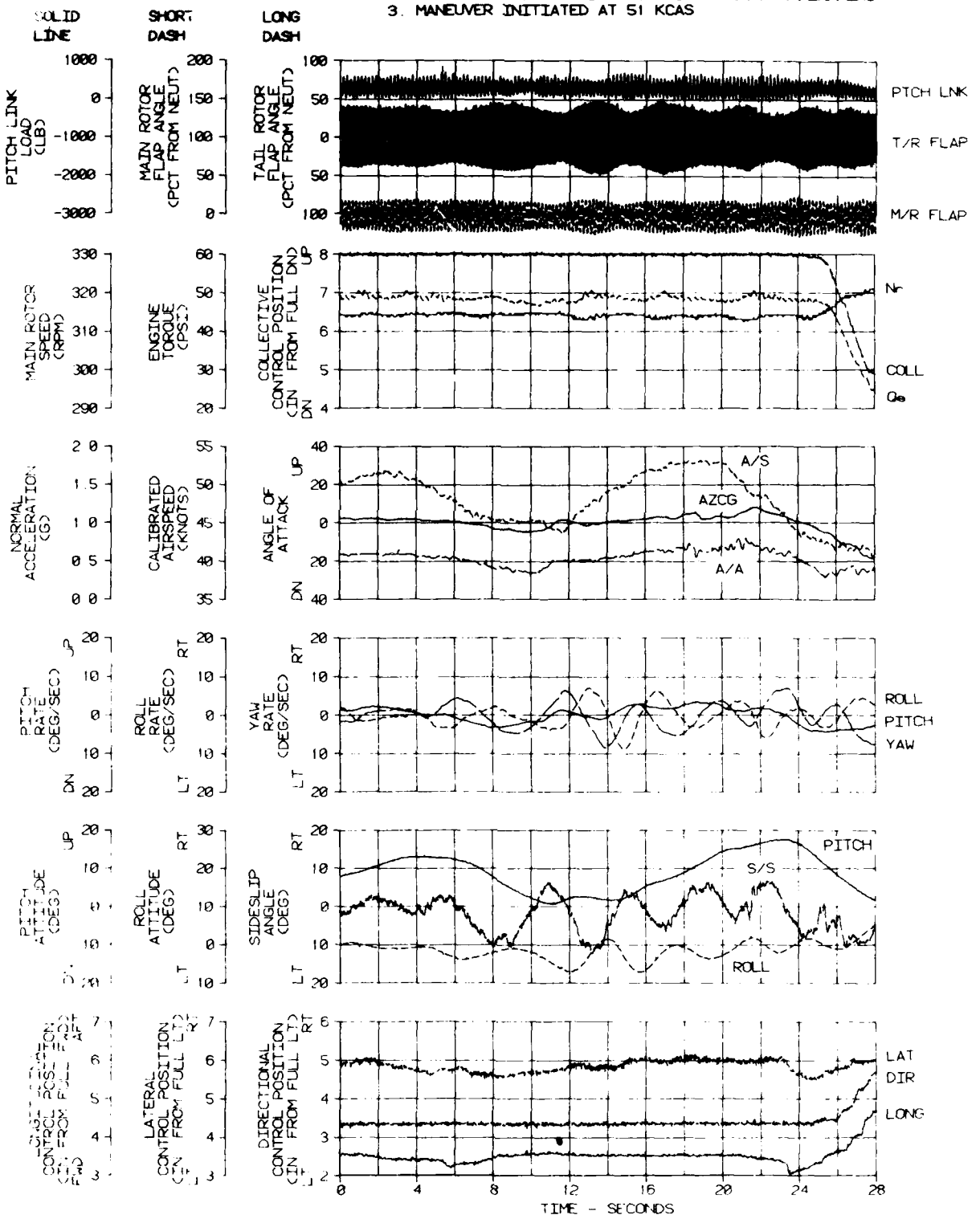


FIGURE E-62

LONGITUDINAL CONTROLLABILITY

UH-1H USA S/N 66-16958

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION FUS (FS)	AT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)	TRIM FLIGHT CONDITION
□	8690	142.5(AFT)	0.0	2970	15.5	313	0	HOVER
○	8650	142.3(AFT)	0.0	1690	8.5	324	8	HOVER

NOTE: CMRB/HUB SPRNG CONFIGURATION

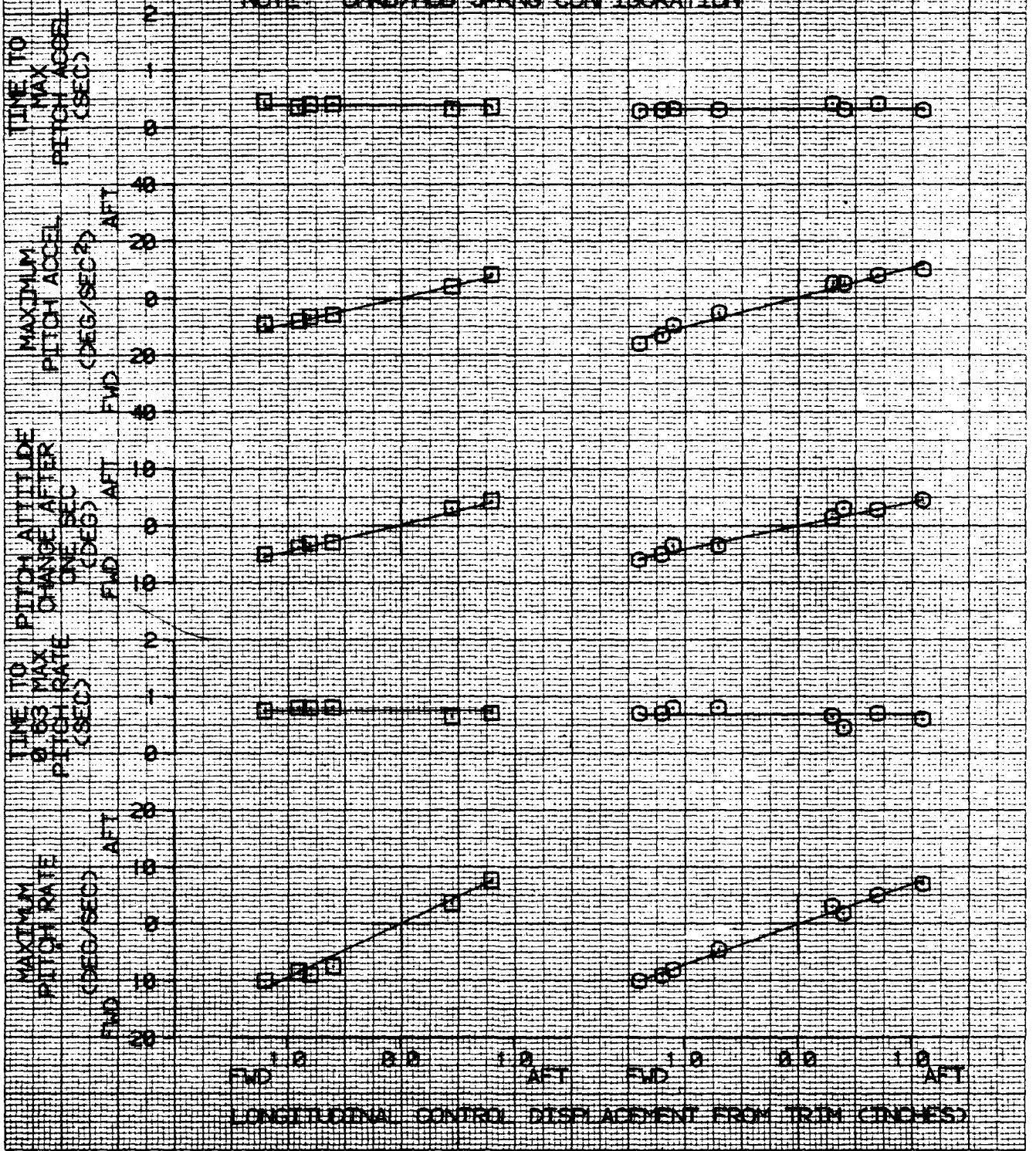


FIGURE 5-63

LONGITUDINAL CONTROL LABILITY

UH-1H USA S/N 68-16053

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRUE CALIBRATED AIRSPEED (KT)	TRIM FLIGHT CONDITION
□	8670	139.4 (FWD)	0	1,100	5050	15.0	324	72	LEVEL
○	8690	139.4 (FWD)	0	1,100	5040	15.0	324	91	LEVEL

NOTE: CHRB/HUB SPRING CONFIGURATION

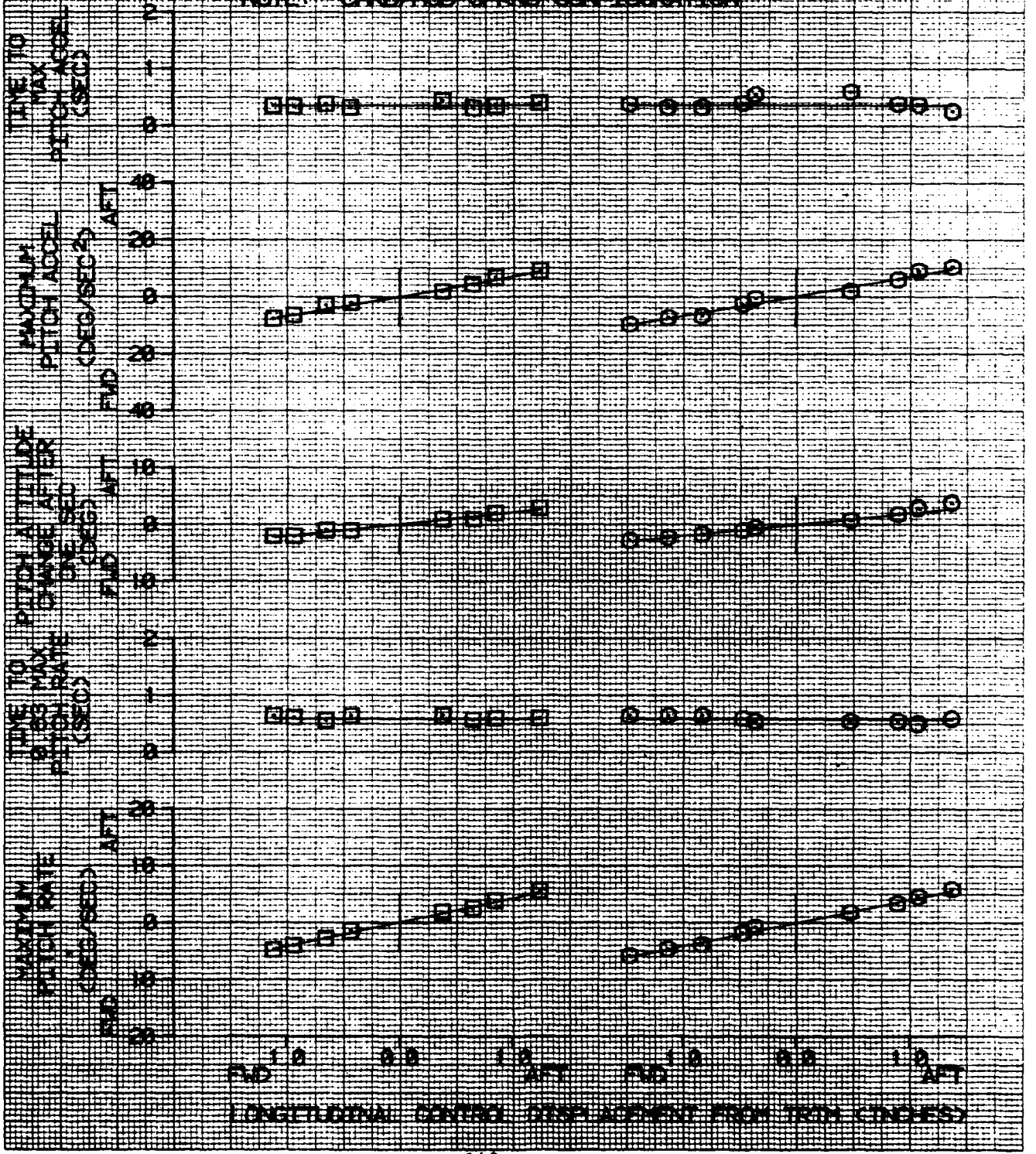


FIGURE 8-64

LONGITUDINAL CONTROLLABILITY

UH-1H USA S/N 66-16358

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)	TRIM FLIGHT CONDITION
⊡	8660	142.4(AFT)	0.0	6090	4.0	314	76	LEVEL
⊙	8450	142.2(AFT)	0.1LT	5940	8.5	314	96	LEVEL

NOTE: CMRB/HUB SPRNG CONFIGURATION

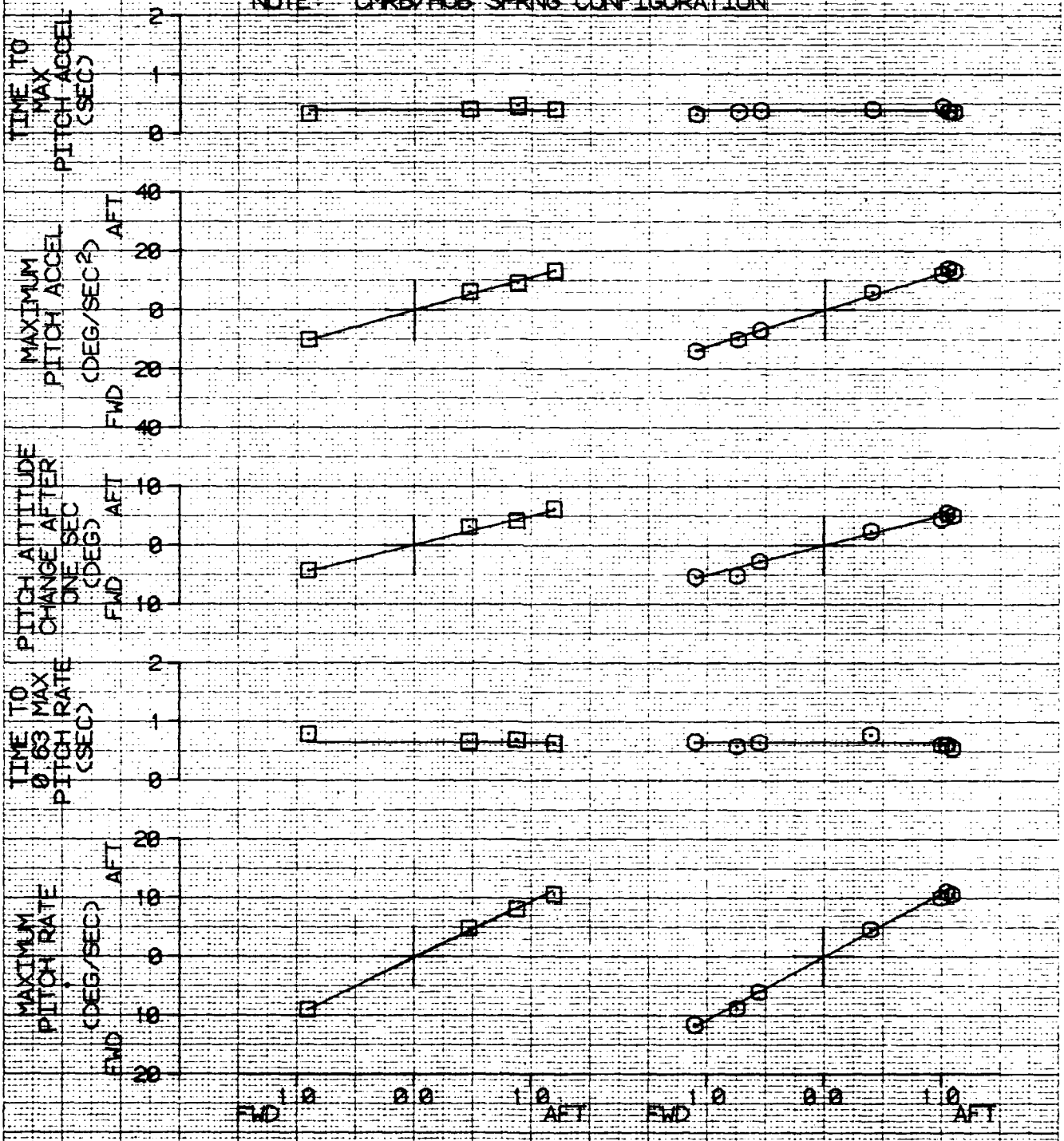


FIGURE E-65

LONGITUDINAL CONTROLLABILITY

UH-1H USA S/N 68-16358

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)	TRIM FLIGHT CONDITION
□	8110	141.2(AFT)	0.1LT	5900	12.0	324	55	MAX PWR CLMB
○	8110	141.2(AFT)	0.1LT	6170	7.5	324	60	AUTO

NOTE: CMRB/HUB SPRNG CONFIGURATION

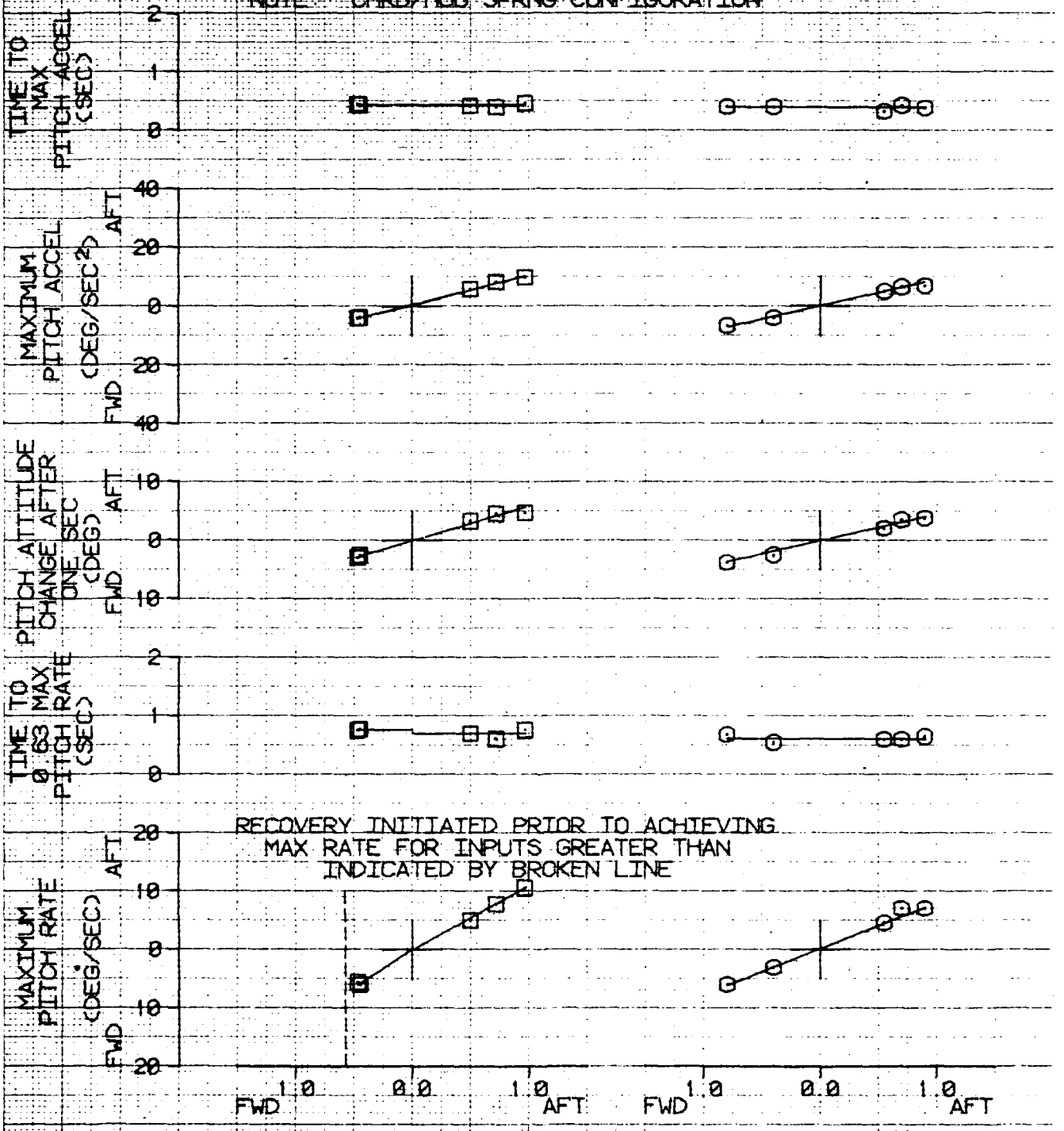


FIGURE E-66

LONGITUDINAL STEP IN MAXIMUM POWER CLIMB

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)
8090	140.9(AFT)	0.0	5910	12.5	324	57

NOTES: 1. CMRB/HUB SPRNG CONFIGURATION
2. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

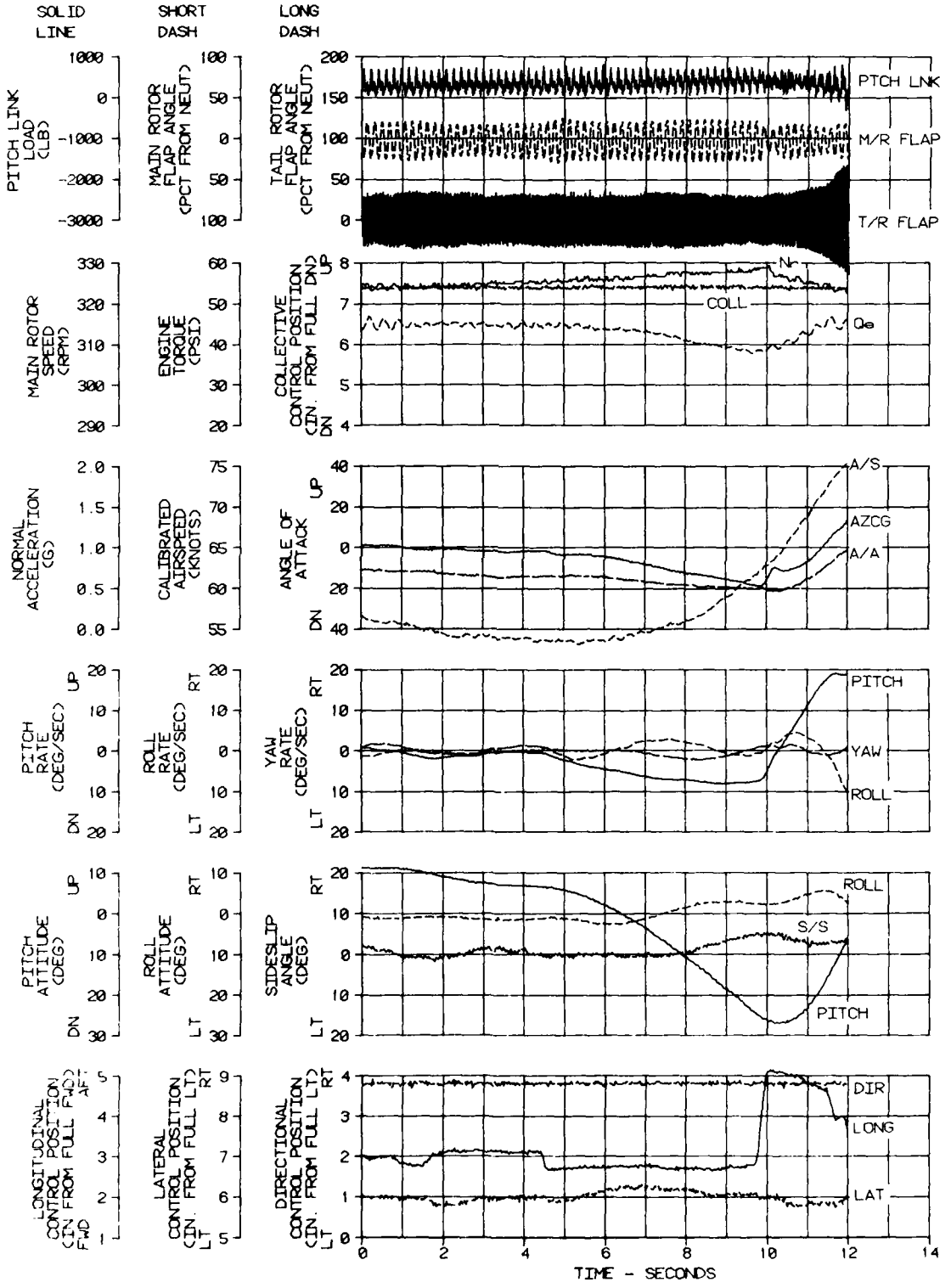


FIGURE E-67

LONGITUDINAL STEP IN AUTOROTATION

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)
7980	140.9(AFT)	0.0	6170	7.5	322	60

NOTES: 1. CMRB/HUB SPRNG CONFIGURATION
2. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

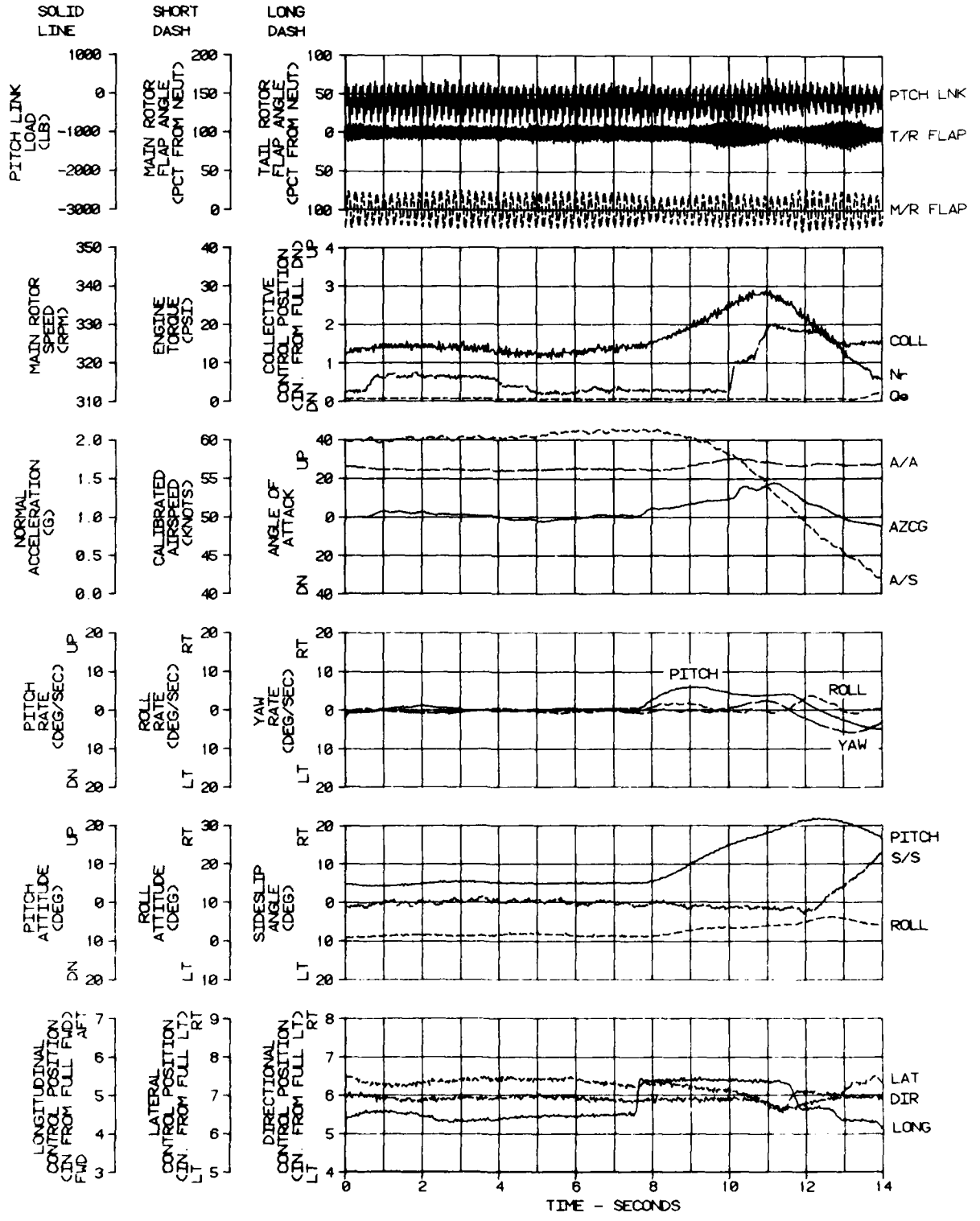


FIGURE B-66

LATERAL CONTROLLABILITY

UH-1H USA S/N 68-16358

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)	TRIM FLIGHT CONDITION
□	6980	142.4(AFT)	0.0	1530	6.5	314	0	HOVER
○	6190	140.9(AFT)	0.0	2080	11.0	323	0	HOVER

NOTE: CMR6/HUB SPRNG CONFIGURATION

TIME TO MAX ROLL ACCEL (SEC)

MAXIMUM ROLL ACCEL (DEG/SEC2)

ROLL ATTITUDE CHANGE AFTER 0.5 SEC (DEG)

TIME TO 0.63 MAX ROLL RATE (SEC)

MAXIMUM ROLL RATE (DEG/SEC)

LT 10 00 10 RT LT 10 00 10 RT

LATERAL CONTROL DISPLACEMENT FROM TRIM (INCHES)

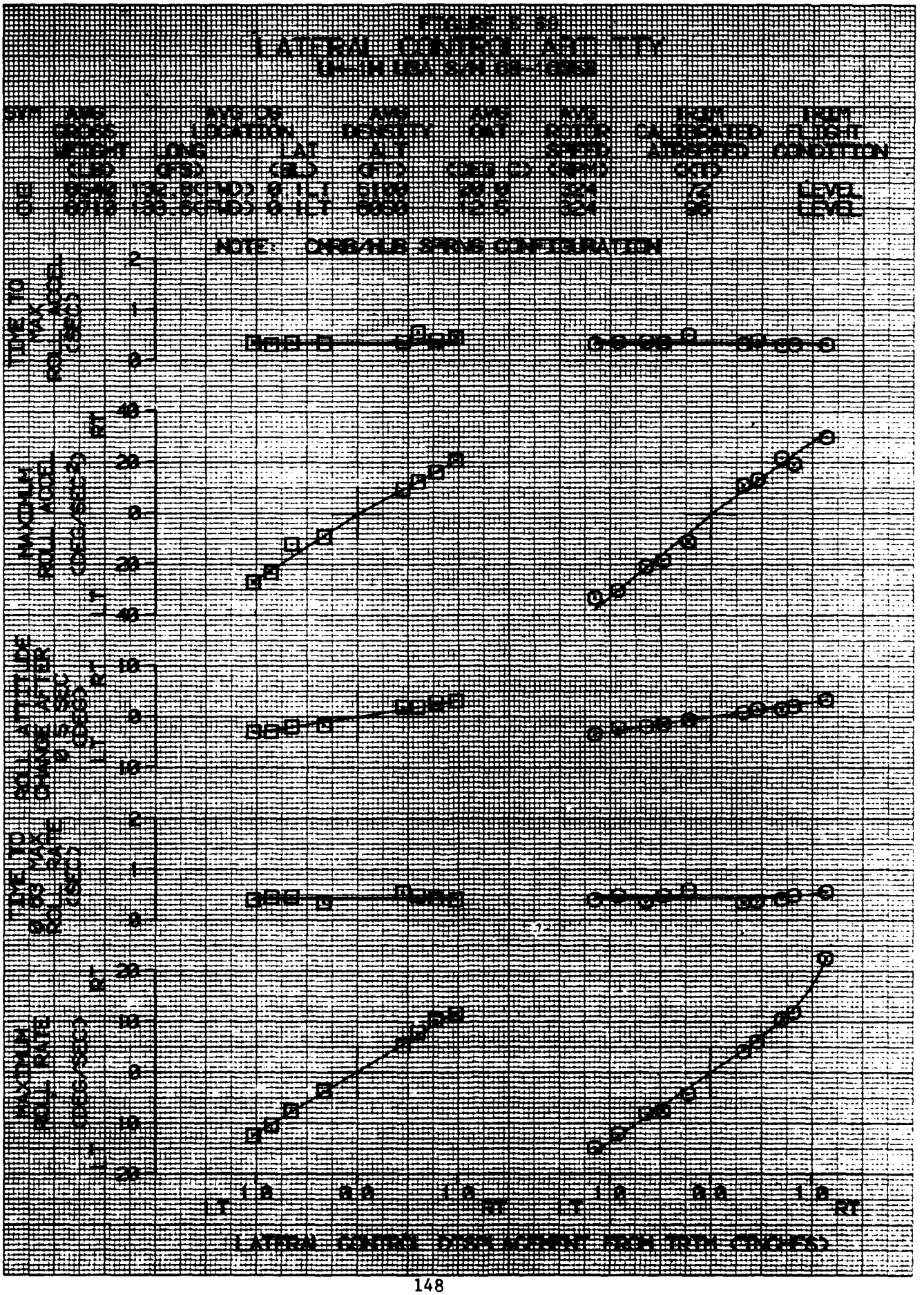

NOTE: DASH-LINE SPRING CONFIGURATION
LATERAL CONTROL DISPLACEMENT FROM TRIM (INCHES)

FIGURE E-70

LATERAL CONTROLLABILITY

UH-1H USA S/N 68-16358

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)	TRIM FLIGHT CONDITION
⊡	8600	142.6(AFT)	0 LT	5920	8.5	313	75	LEVEL
⊙	8360	141.9(AFT)	0 LT	5900	8.0	314	96	LEVEL

NOTE: CMRB/HUB SPRNG CONFIGURATION

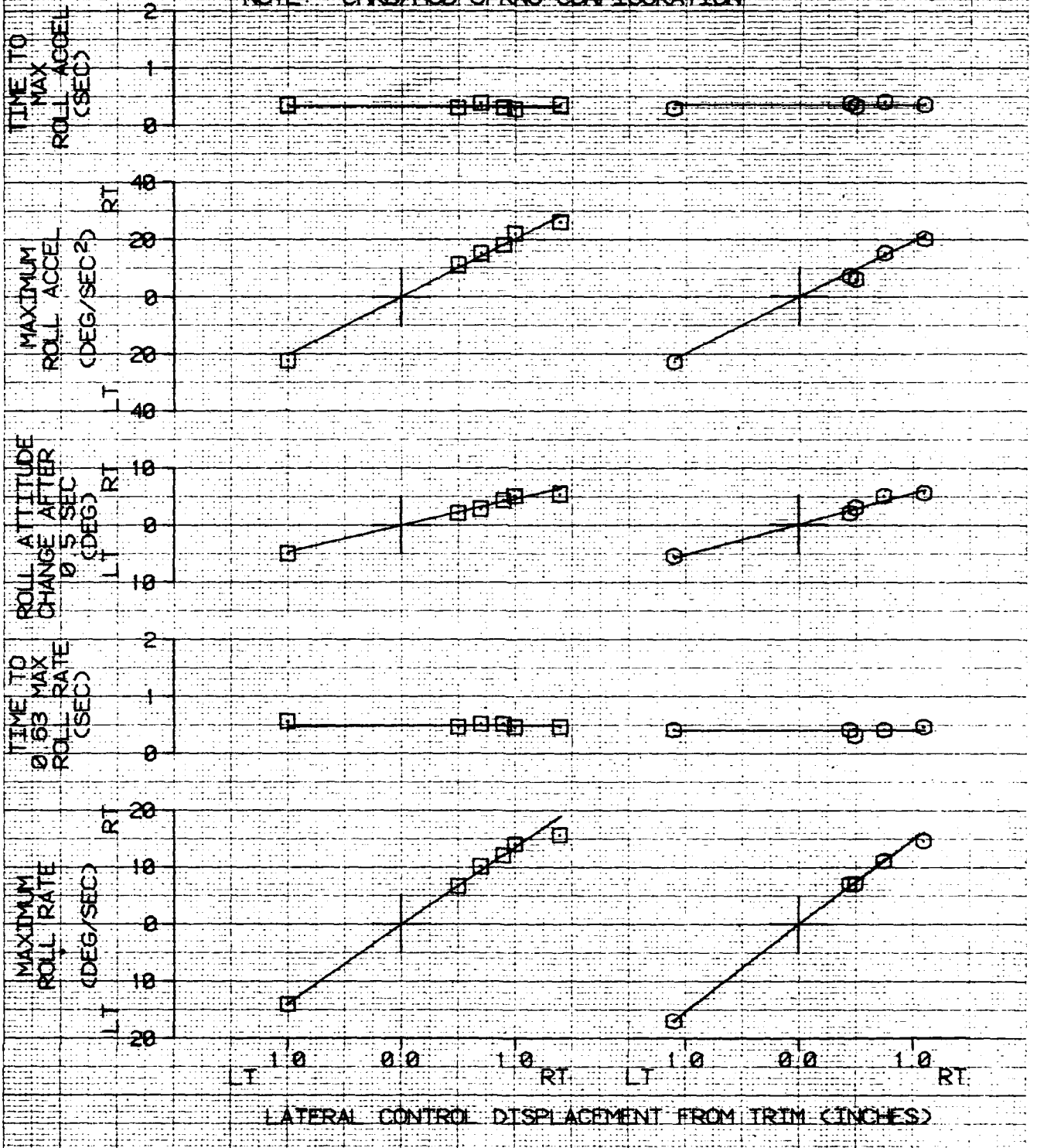


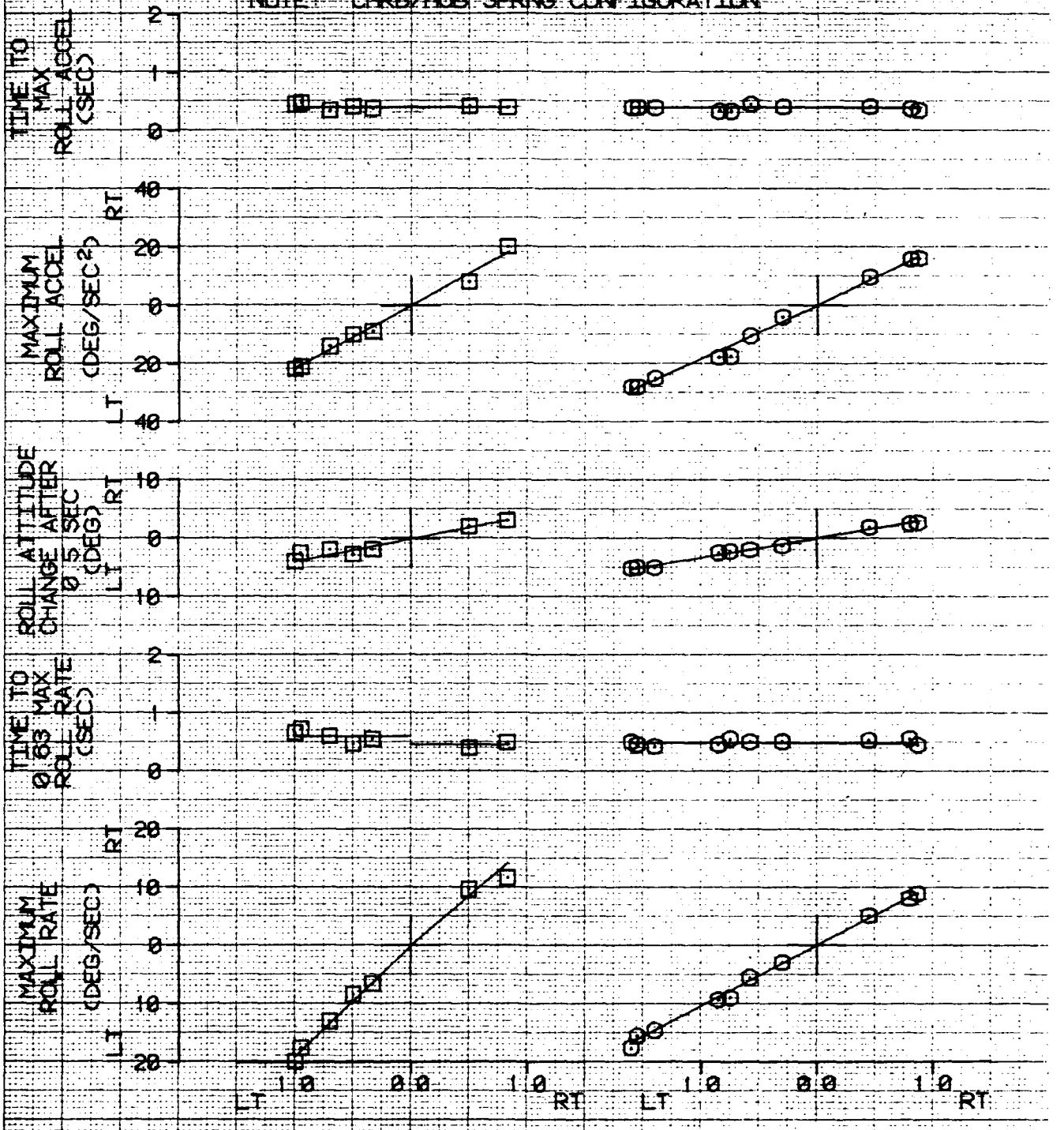
FIGURE E-71

LATERAL CONTROL ABILITY

UH-1H USA S/N 68-16358

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)	TRIM FLIGHT CONDITION
□	8500	142.3 (AFT)	0.1 LT	5900	13.0	324	55	MAX PWR CLMB
○	8450	142.0 (AFT)	0.1 LT	5900	9.0	323	62	AUTO

NOTE: CMRB/HUB SPRNG CONFIGURATION



LATERAL CONTROL DISPLACEMENT FROM TRIM (INCHES)

FIGURE E-72

DIRECTIONAL CONTROL ABILITY

UH-1H USA S/N 68-16358

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)	TRIM FLIGHT CONDITION
□	8570	141.1 (AFT)	0.0	1630	8.5	314	0	HOVER
○	7900	140.9 (AFT)	0.0	2420	14.0	324	0	HOVER

NOTE: CMRB/HUB SPRNG CONFIGURATION

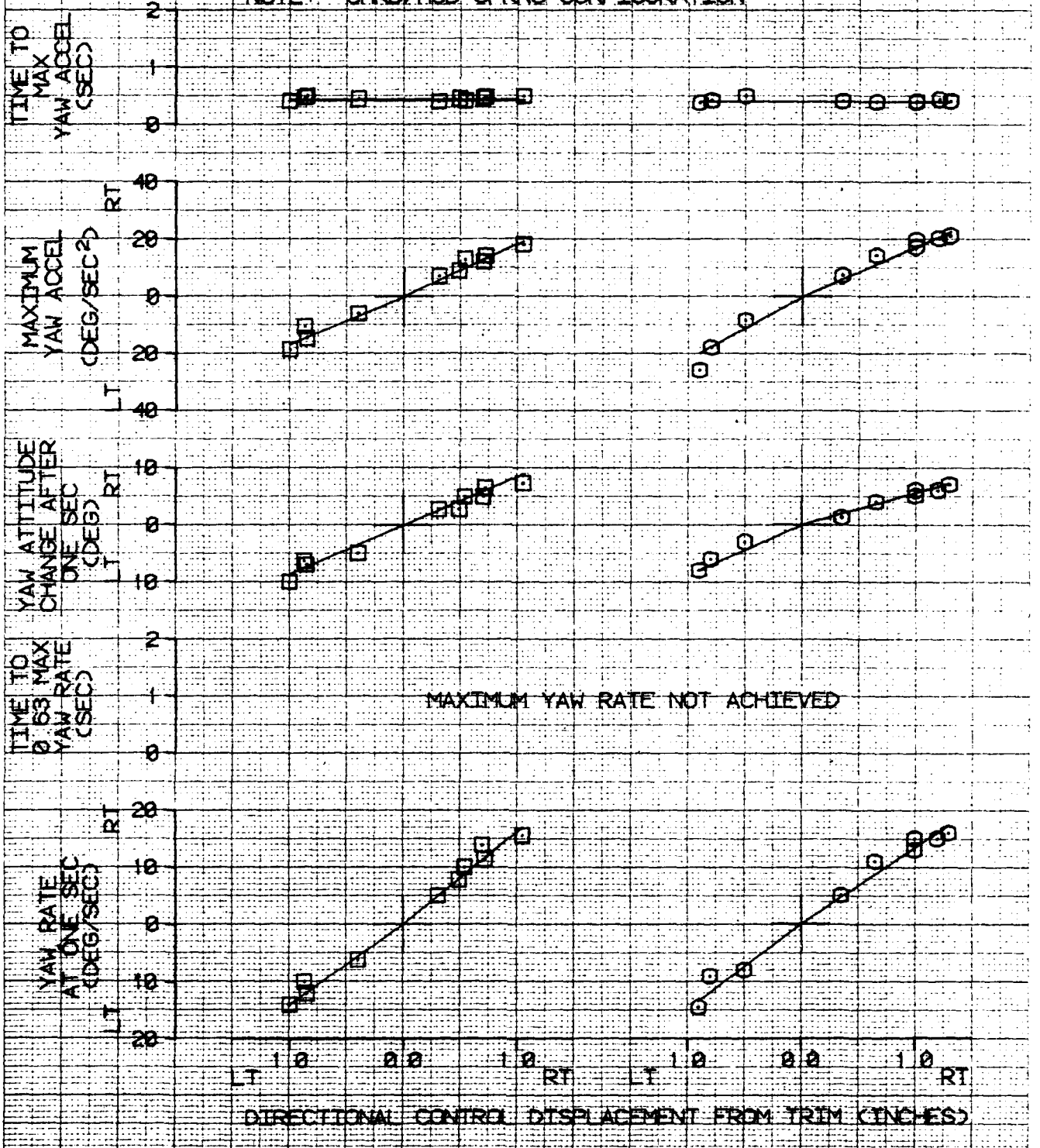


FIGURE E-73

DIRECTIONAL CONTROLLABILITY

UH-1H USA S/N 68-16358

SYM	GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	DENSITY ALT (FT)	OAT (DEG C)	ROTOR SPEED (RPM)	TRIM TRUE AIRSPEED (KT)	TRIM FLIGHT CONDITION
□	8660	133.8(FWD)	0.0	10400	2.5	314	15	LOWSPEED
○	7990	131.1(FWD)	0.1RT	750	2.5	314	25	LOWSPEED
△	7970	131.1(FWD)	0.1RT	780	2.5	315	30	LOWSPEED

NOTES: 1. CMRB/HUB SPRNG CONFIGURATION
2. DASHED LINES OBTAINED FROM FIG. 72 IN HOVER AT A ROTOR SPEED OF 314 RPM.

RELATIVE WIND AZIMUTH (DEGREES FROM NOSE)

90 DEG 225 DEG 270 DEG

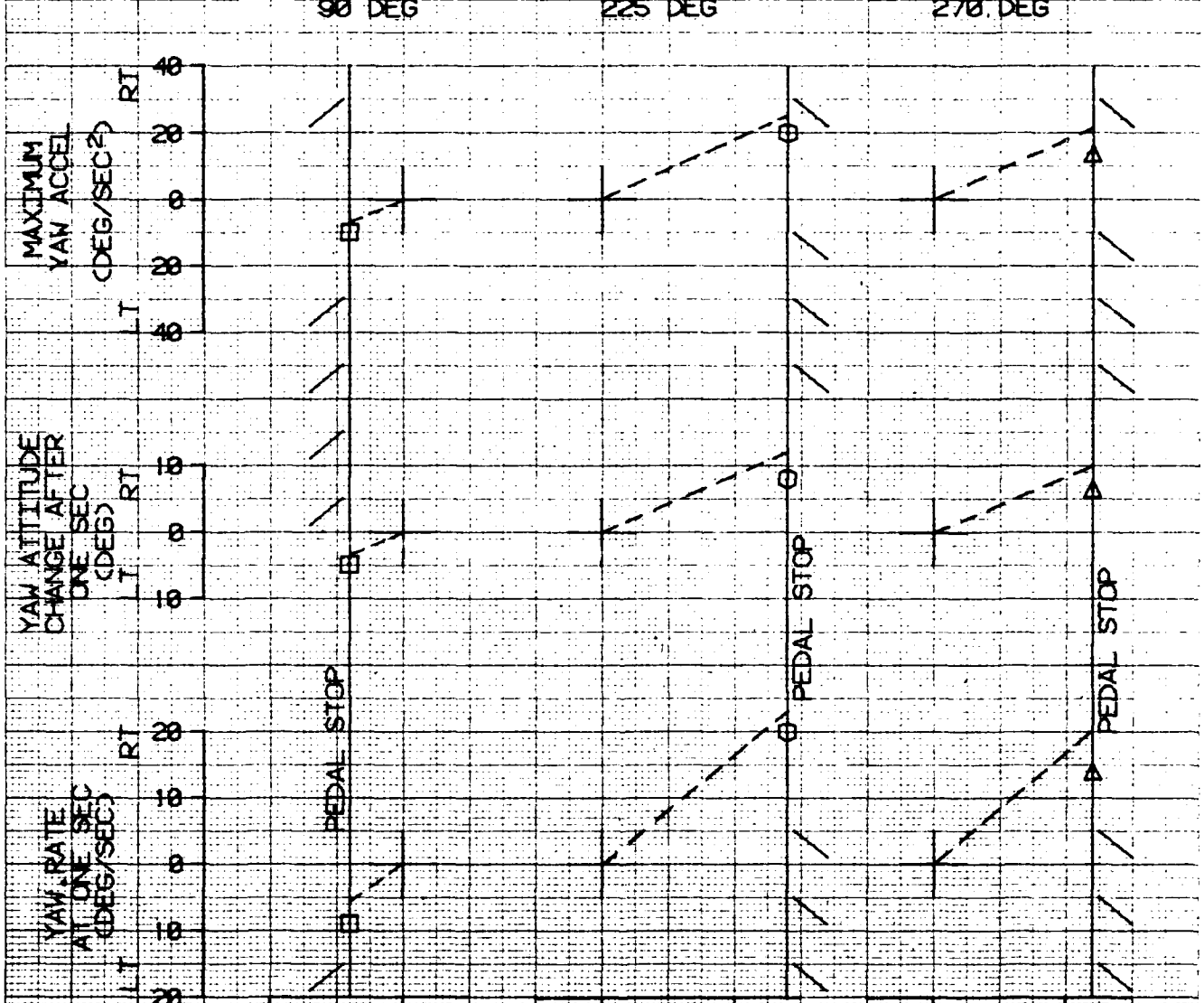


FIGURE E-74

DIRECTIONAL CONTROLLABILITY

UH-1H USA S/N 68-16358

SYM	AVG GROSS WEIGHT (LBS)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)	TRIM FLIGHT CONDITION
□	8170	131.4(FWD)	0.1LT	6090	20.0	325	72	LEVEL
○	8370	132.3(FWD)	0.1LT	6120	12.5	324	96	LEVEL

NOTE: CMRB/HUB SPRNG CONFIGURATION

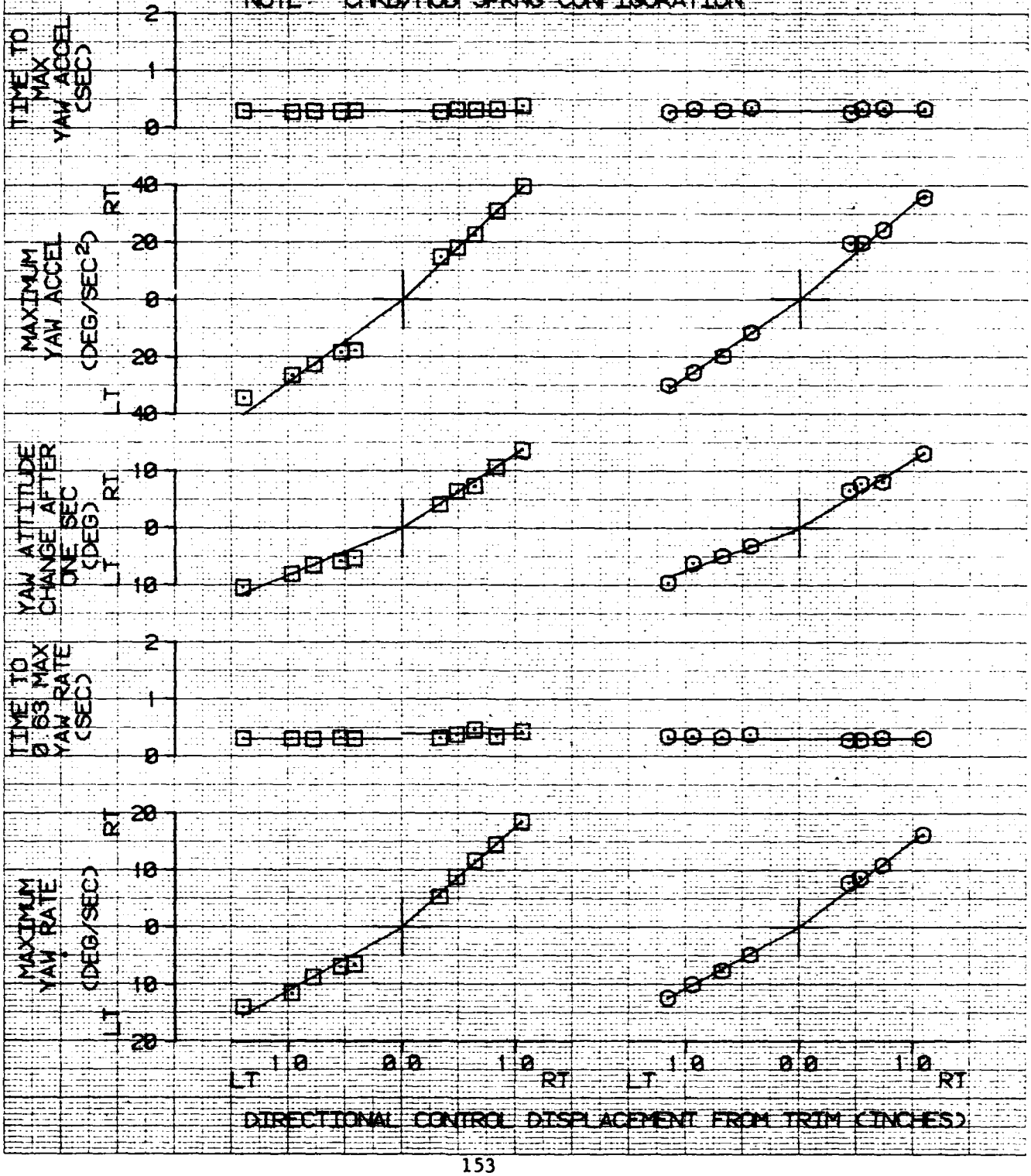


FIGURE E-75

DIRECTIONAL CONTROL ABILITY

UH-1N USA S/N 68-16368

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (IN.)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)	TRIM FLIGHT CONDITION
□	8400	141.8(AFT)	0.0	6040	4.0	314	75	LEVEL
○	8600	141.4(AFT)	0.0	6050	3.5	314	95	LEVEL

NOTE: CMRB/HUB SPRING CONFIGURATION

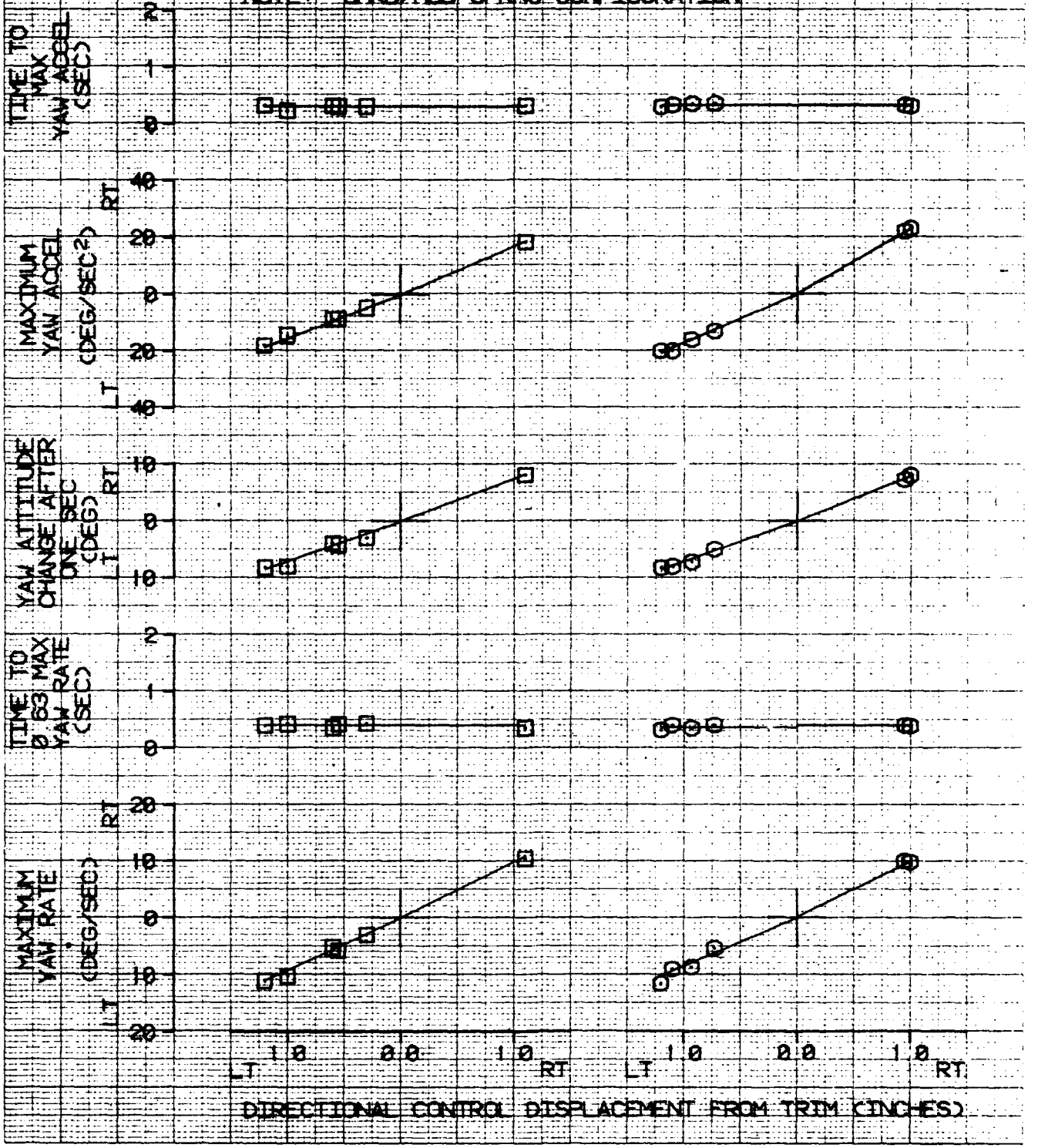


FIGURE E-76

DIRECTIONAL CONTROL ABILITY

UH-1H USA S/N 68-16358

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)	TRIM FLIGHT CONDITION
⊡	8600	142.6(AFT)	0.1 LT	6020	13.0	324	52	MAX PWR CLMB
⊙	8520	142.4(AFT)	0.1 LT	6200	14.0	323	59	AUTO

NOTE: CMRB/HUB SPRNG CONFIGURATION

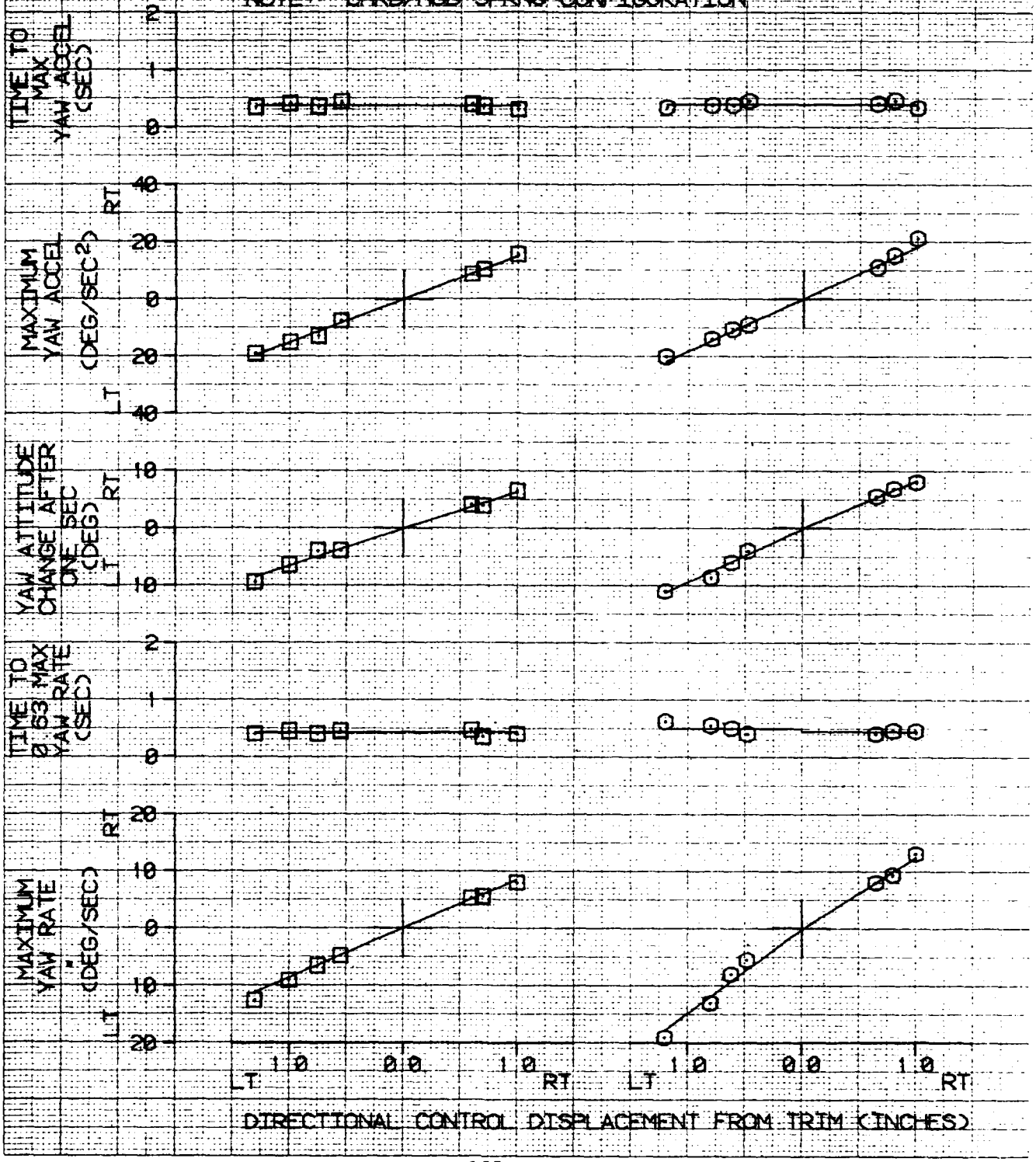


FIGURE E-77

DIRECTIONAL STEP IN AUTOROTATIONAL DESCENT

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)
8470	142.2 (AFT)	0.0	6320	13.5	325	62

NOTES: 1. CMRB/HUB SPRNG CONFIGURATION
2. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

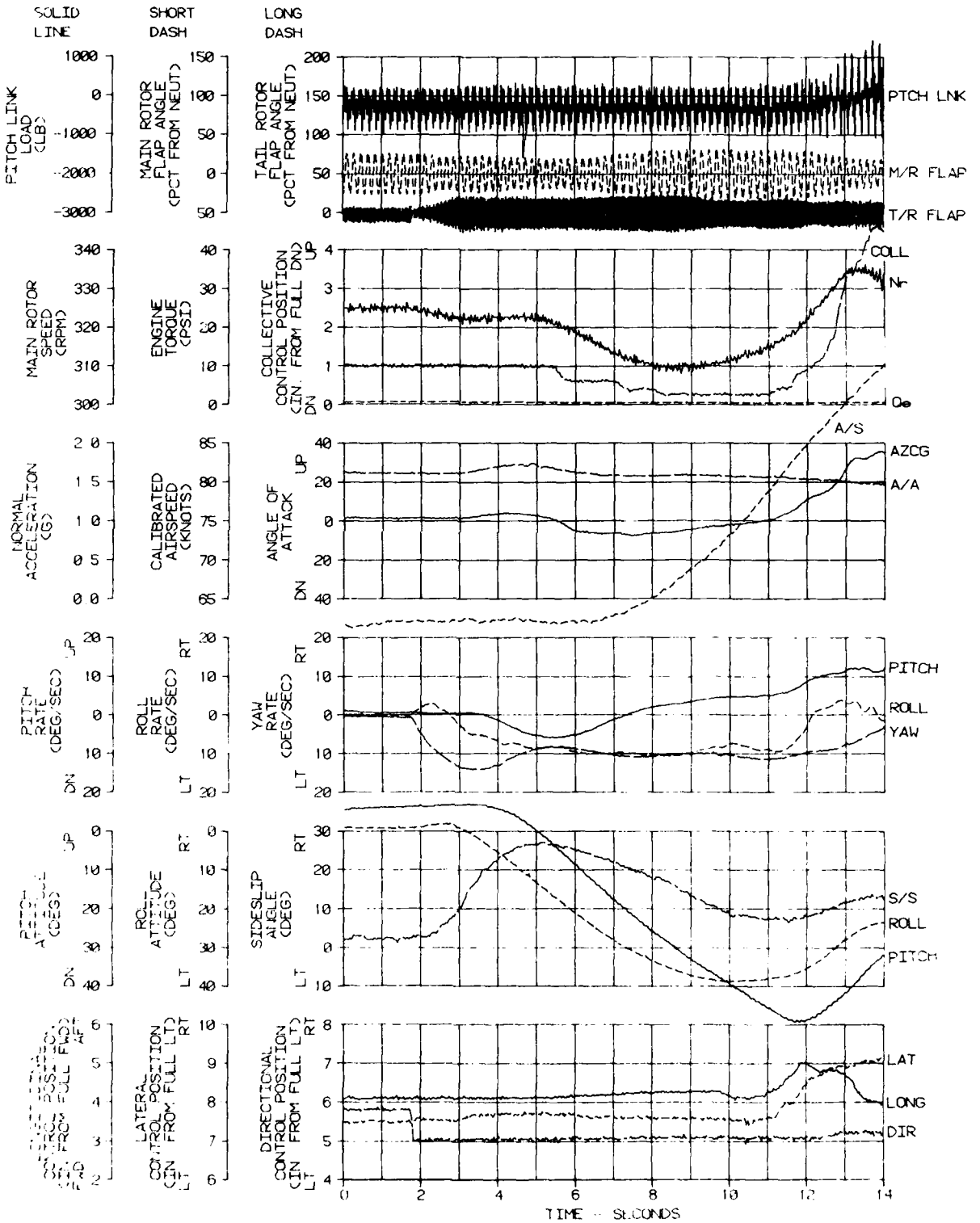


FIGURE E-78

TRANSLATIONAL FLIGHT CONTROL MARGIN SUMMARY
UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	AVG SKID HEIGHT (FT)
8520	133.0(FWD)	0.0	700	2.0	315	13

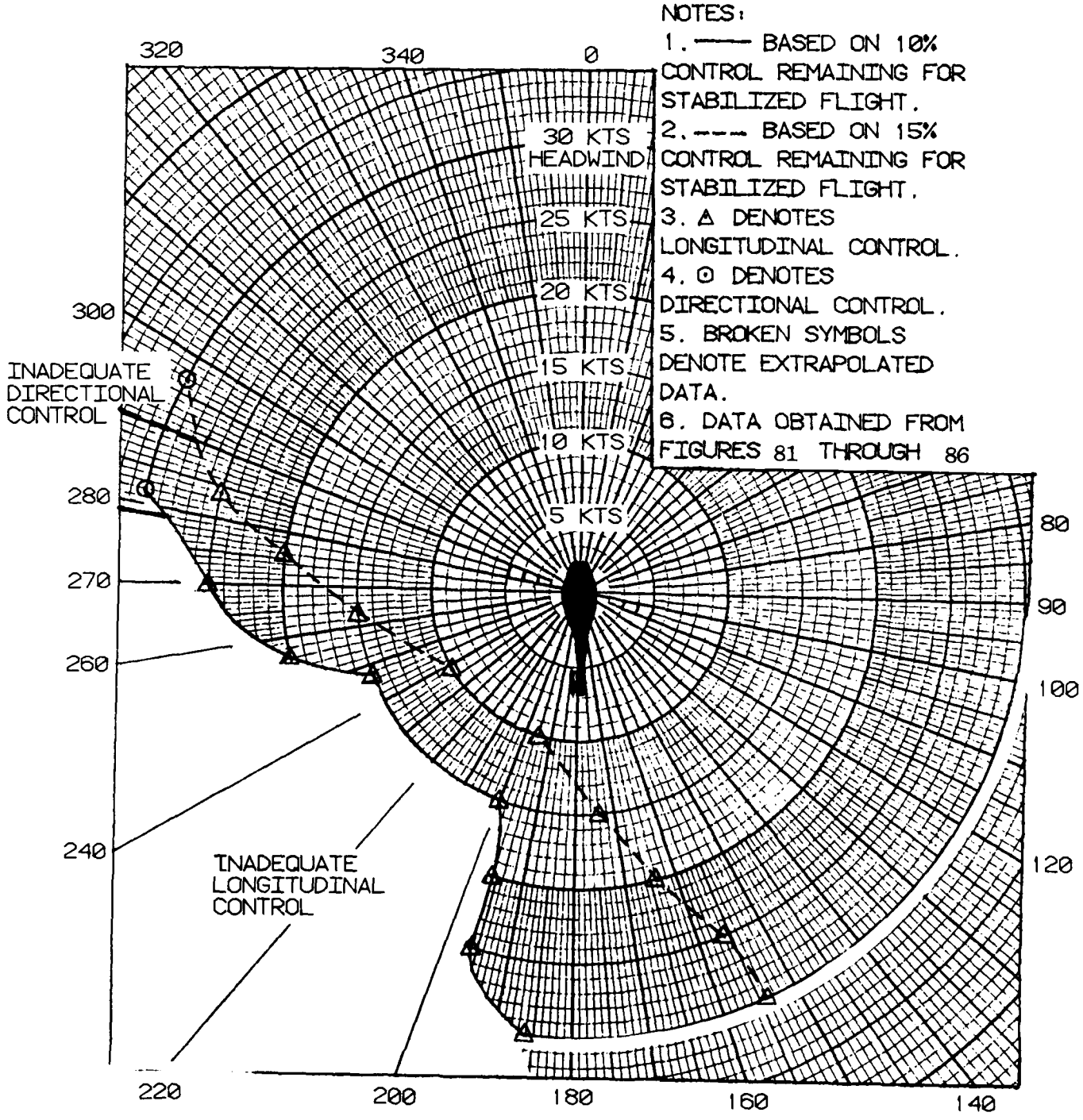


FIGURE E-79

TRANSLATIONAL FLIGHT CONTROL MARGIN SUMMARY
UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	AVG SKID HEIGHT (FT)
8560	133.0(FWD)	0.0	4360	10.0	314	12

NOTES:
1. —— BASED ON 10% CONTROL REMAINING FOR STABILIZED FLIGHT.
2. - - - BASED ON 15% CONTROL REMAINING FOR STABILIZED FLIGHT.
3. △ DENOTES LONGITUDINAL CONTROL.
4. ⊙ DENOTES DIRECTIONAL CONTROL.
5. BROKEN SYMBOLS DENOTE EXTRAPOLATED DATA.
6. DATA OBTAINED FROM FIGURES 87 THROUGH 92 .

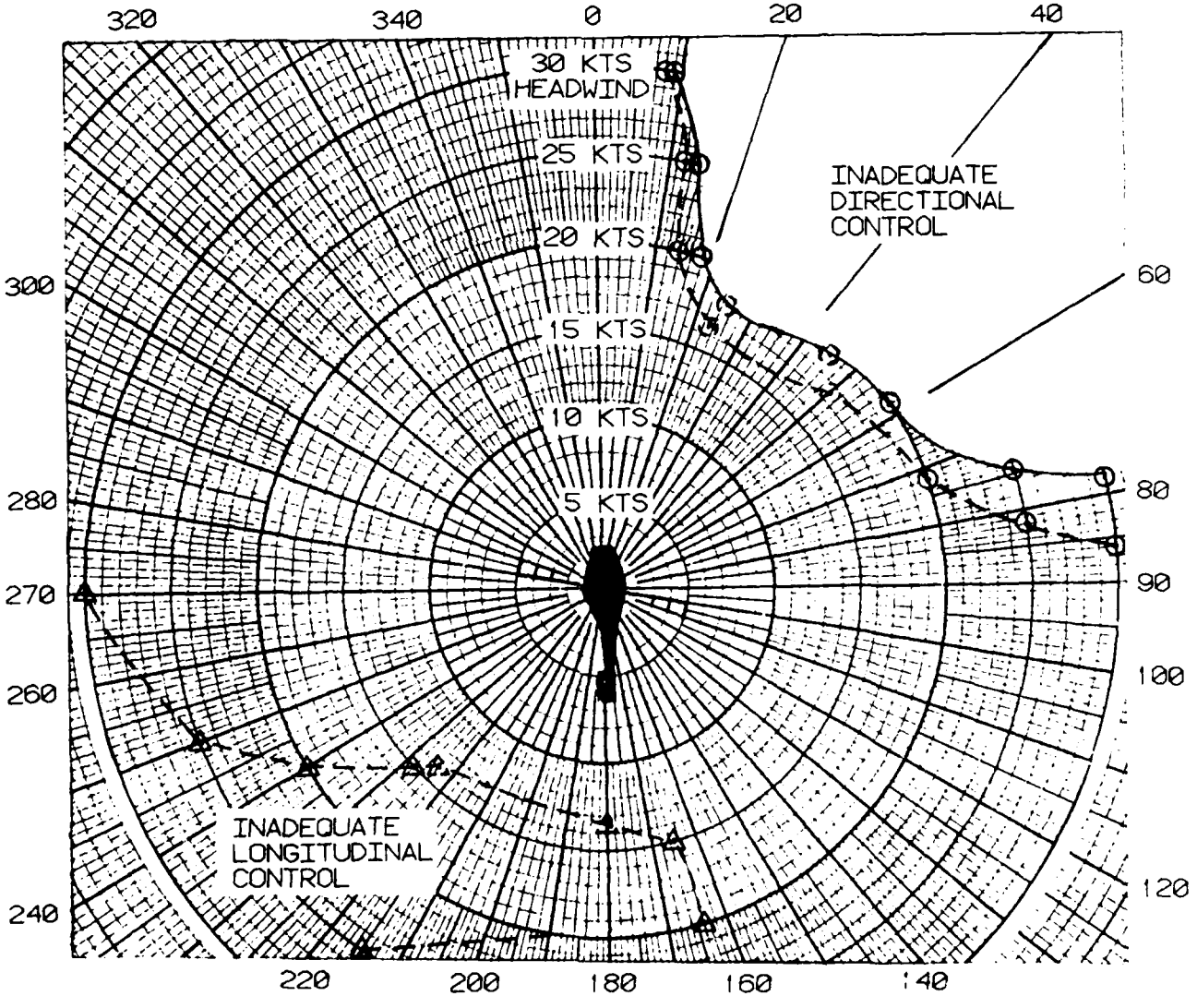
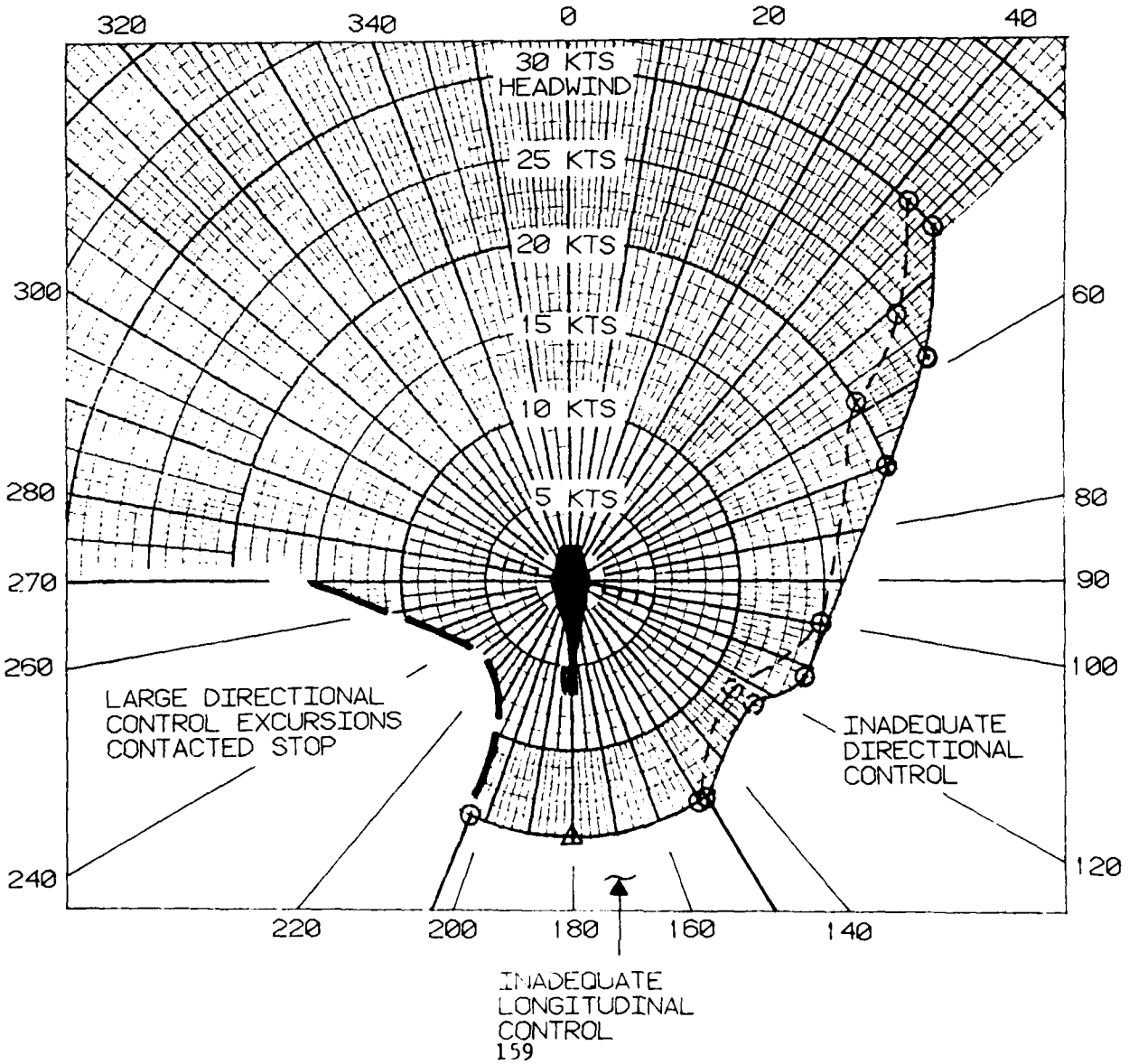


FIGURE E-80

TRANSLATIONAL FLIGHT CONTROL MARGIN SUMMARY
UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	AVG SKID HEIGHT (FT)
8490	133.1(FWD)	0.0	10490	3.5	315	13

NOTES:
1. —— BASED ON 10% CONTROL REMAINING FOR STABILIZED FLIGHT.
2. _ _ _ BASED ON 15% CONTROL REMAINING FOR STABILIZED FLIGHT.
3. Δ DENOTES LONGITUDINAL CONTROL.
4. ⊙ DENOTES DIRECTIONAL CONTROL.
5. BROKEN SYMBOLS DENOTE EXTRAPOLATED DATA.
6. DATA OBTAINED FROM FIGURES 93 THROUGH 98.



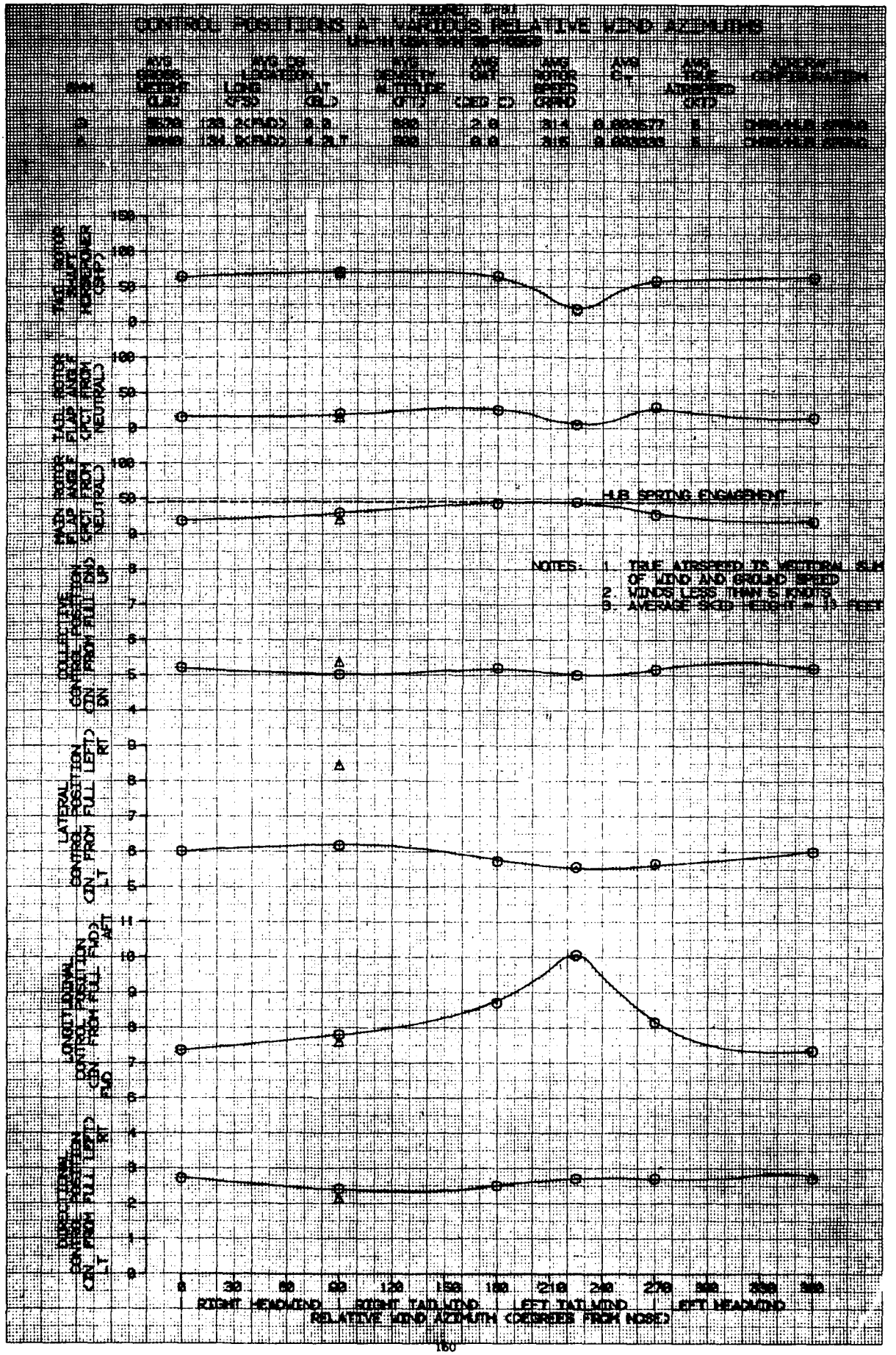

CONTROL POSITIONS AT VARIOUS RELATIVE WIND AZIMUTHS
HUB SPRING ENGAGEMENT
NOTES: 1. TRUE AIRSPEED IS VECTORIAL SUM OF WIND AND GROUND SPEED
2. WINDS LESS THAN 5 KNOTS
3. AVERAGE SKID HEIGHT = 10 FEET
MAIN ROTOR TAIL ROTOR FLAP ANGLE FLAP ANGLE TORQUE PEDAL POSITION (PCT FROM (PCT FROM (PCT FROM NEUTRAL) NEUTRAL) NEUTRAL)
COLLECTIVE CONTROL POSITION (IN FROM FULL DN) UP DN
LATERAL CONTROL POSITION (IN FROM FULL LEFT) RT LT
LONGITUDINAL CONTROL POSITION (IN FROM FULL FWD) AFT FWD
DIRECTIONAL CONTROL POSITION (IN FROM FULL LEFT) RT LT
RIGHT HEADWIND
RIGHT TAIL WIND
LEFT TAIL WIND
LEFT HEADWIND
RELATIVE WIND AZIMUTH (DEGREES FROM NOSE)

FIGURE A-32

CONTROL POSITIONS AT VARIOUS RELATIVE WIND AZIMUTHS

(GW=14,000 LB; CG AT 352.0 INCHES)

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FSTA)	AVG CG LOCATION LAT (BL)	AVG PRESSURE ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	AVG CAS	AVG TRUE AIRSPEED (KNOTS)	AVG DENSITY ALTITUDE (FT)
○	14000	138.1 (FWD)	0.3 RT	2020	2.8	314	0.66	48	2080
△	14000	138.3 (FWD)	4.2 LT	4080	6.8	314	0.66	48	4140

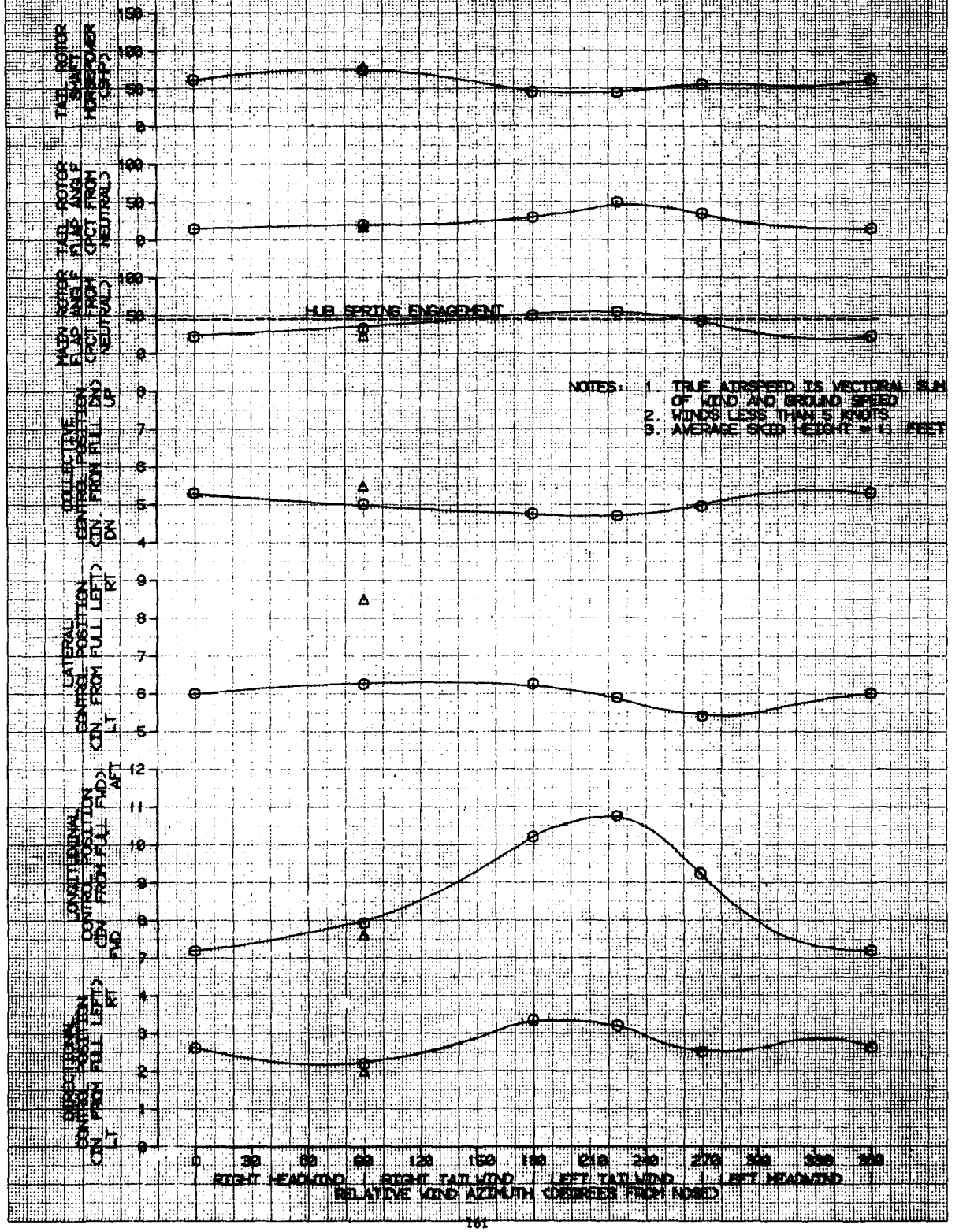


FIGURE E-88

CONTROL POSITIONS AT VARIOUS RELATIVE WIND AZIMUTHS

UH-1H USA S/N 70-16558

RUN	AVG GROSS WEIGHT (LBS)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	AVG C_T	AVG TRUE AIRSPEED (KT)	AIRCRAFT CONFIGURATION
○	8580	139.1 (FWD)	0.0	720	2.0	315	0.003231	15	CHINOOK SPREAD
△	8610	134 (AFT)	4 RT	410	0.0	314	0.003217	15	CHINOOK SPREAD

NOTES:
1. TRUE AIRSPEED IS VECTORIAL SUM OF WIND AND GROUND SPEED
2. WINDS LESS THAN 5 KNOTS
3. AVERAGE SKID HEIGHT = 2½ FEET

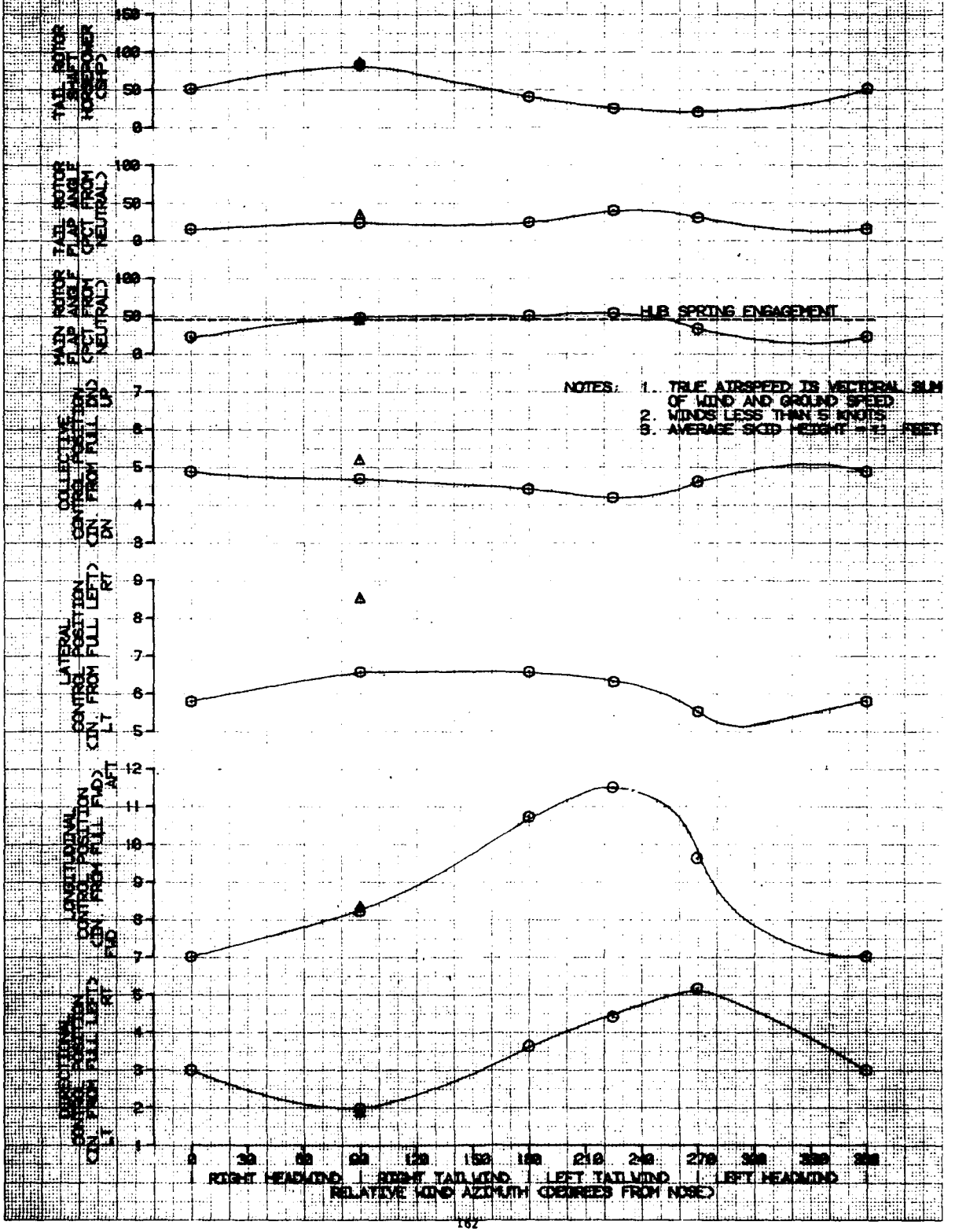


FIGURE 2-31

CONTROL POSITIONS AT VARIOUS RELATIVE WIND AZIMUTHS

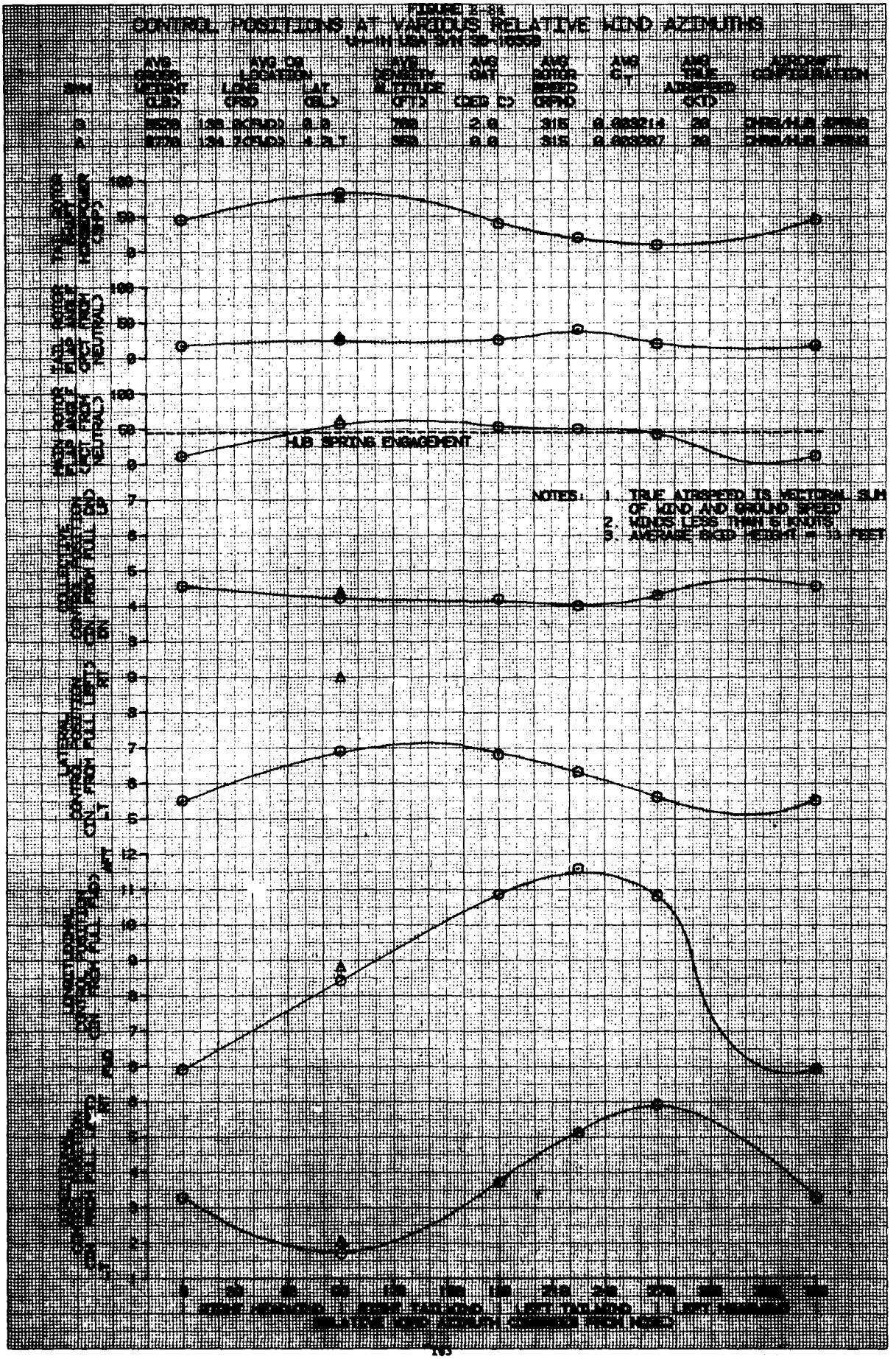


FIGURE 2-45

CONTROL POSITIONS AT VARIOUS RELATIVE WIND AZIMUTHS

UH-1H USA S/N 66-16559

SYM	AVG GROSS WEIGHT (LBS)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALTITUDE (DFD)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	AVG C.T	AVG TRUE AIRSPEED (KTS)	AIRCRAFT CONFIGURATION
O	9200	192 (SCRUD)	0.9	570	2.8	315	0.0062284	25	CRUISE SPEED
A	9200	194 (SCRUD)	4.9 T	520	-1.8	315	0.0062278	25	CRUISE SPEED

NOTES:
1. TRUE AIRSPEED IS VECTORIAL SUM OF WIND AND GROUND SPEED
2. WINDS LESS THAN 5 KNOTS
3. AVERAGE SKID HEIGHT = 5 FEET

FIGURE D-88

CONTROL POSITIONS AT VARIOUS RELATIVE WIND AZIMUTHS

UH-1H USA S/N 66-16558

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	AVG C_T	AVG TRUE AIRSPEED (KT)	AIRCRAFT CONFIGURATION
○	8470	133.8(FWD)	0.0	360	2.0	315	0.003269	30	CHRD/HUB SPRING
◇	8340	132.5(FWD)	0.0	350	1.0	323	0.003208	30	CHRD/HUB SPRING
△	8740	134.6(FWD)	4.2 LT	380	-0.5	316	0.003262	30	CHRD/HUB SPRING
□	8720	134.5(FWD)	4.2 LT	440	0.0	323	0.003125	30	CHRD/HUB SPRING

TAIL ROTOR SHAFT HORSEPOWER (SHP)

TAIL ROTOR FLAP ANGLE (PCT FROM NEUTRAL)

MAIN ROTOR FLAP ANGLE (PCT FROM NEUTRAL)

HUB SPRING ENGAGEMENT

COLLECTIVE CONTROL POSITION (IN. FROM FULL DN) UP DN

LATERAL CONTROL POSITION (IN. FROM FULL LT) RT LT

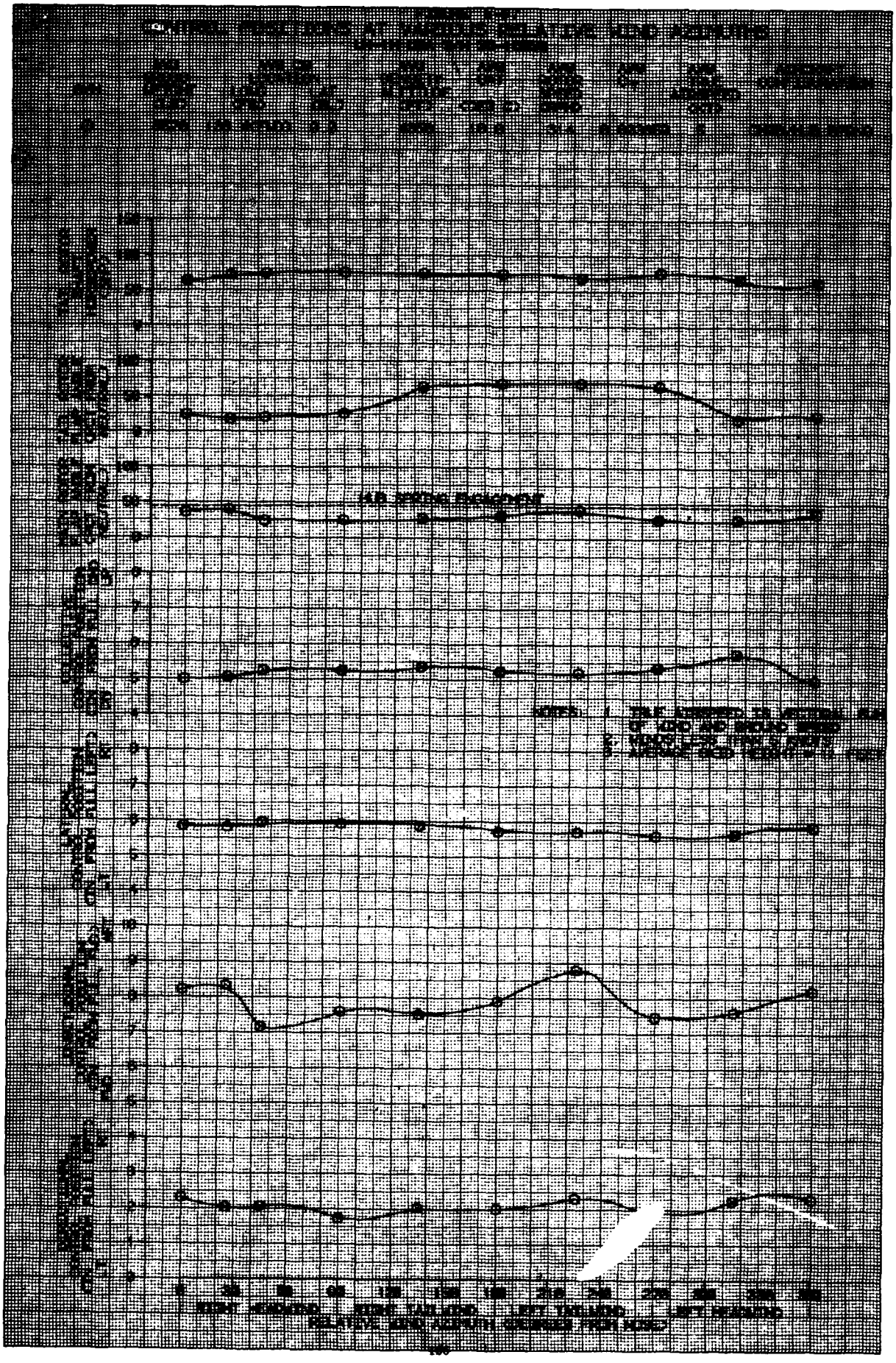
LONGITUDINAL CONTROL POSITION (IN. FROM FULL FWD) AFT

DIRECTIONAL PEDAL POSITION (IN. FROM FULL LT) RT FWD LT

NOTES:
1. TRUE AIRSPEED IS VECTORIAL SUM OF WIND AND GROUND SPEED
2. WINDS LESS THAN 5 KNOTS
3. AVERAGE SKID HEIGHT = 10 FEET

RIGHT HEADWIND | RIGHT TAILWIND | LEFT TAILWIND | LEFT HEADWIND

RELATIVE WIND AZIMUTH (DEGREES FROM NOSE)


RELATIVE WIND AZIMUTH DEGREES FROM NOSE

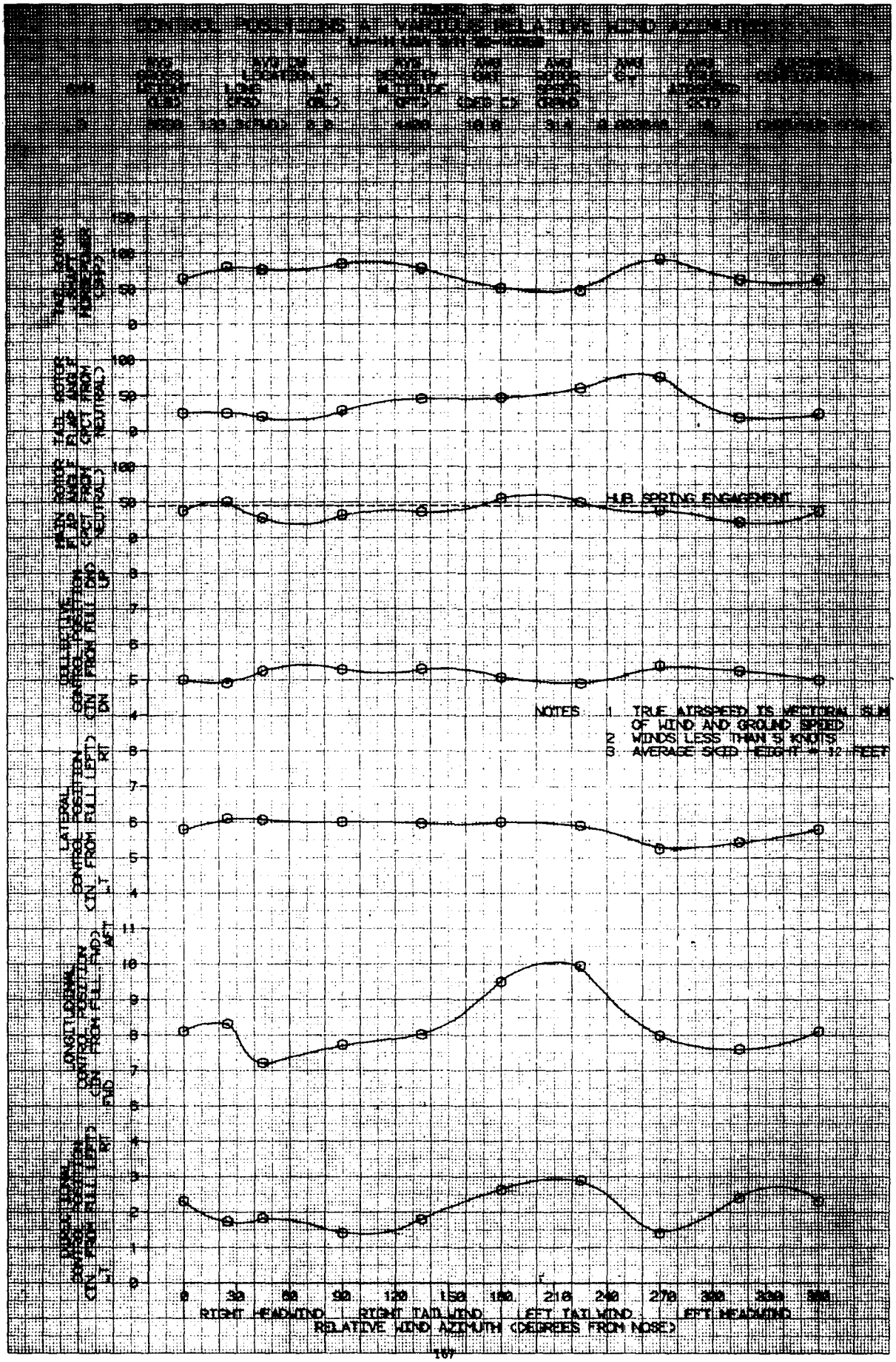
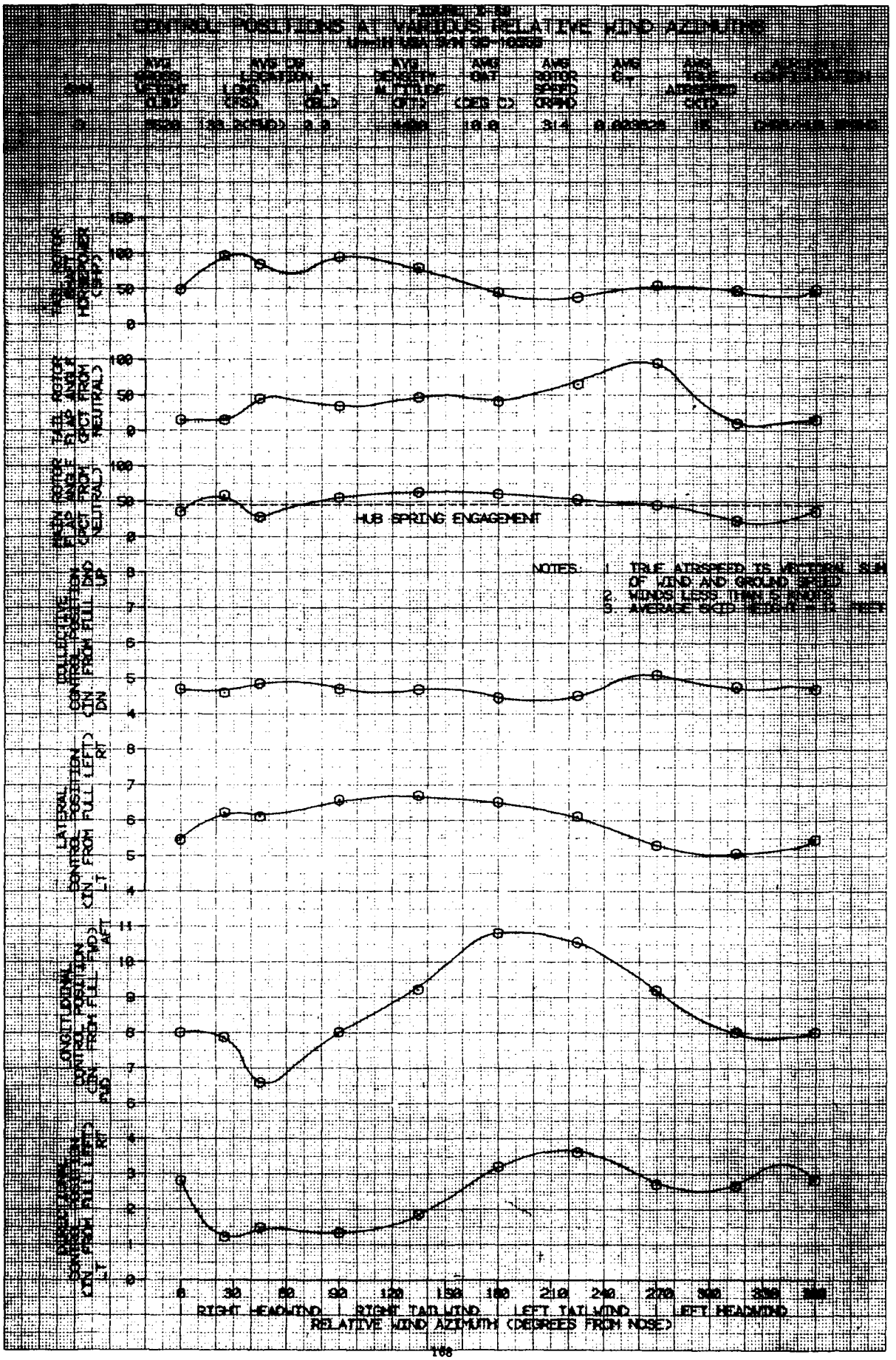
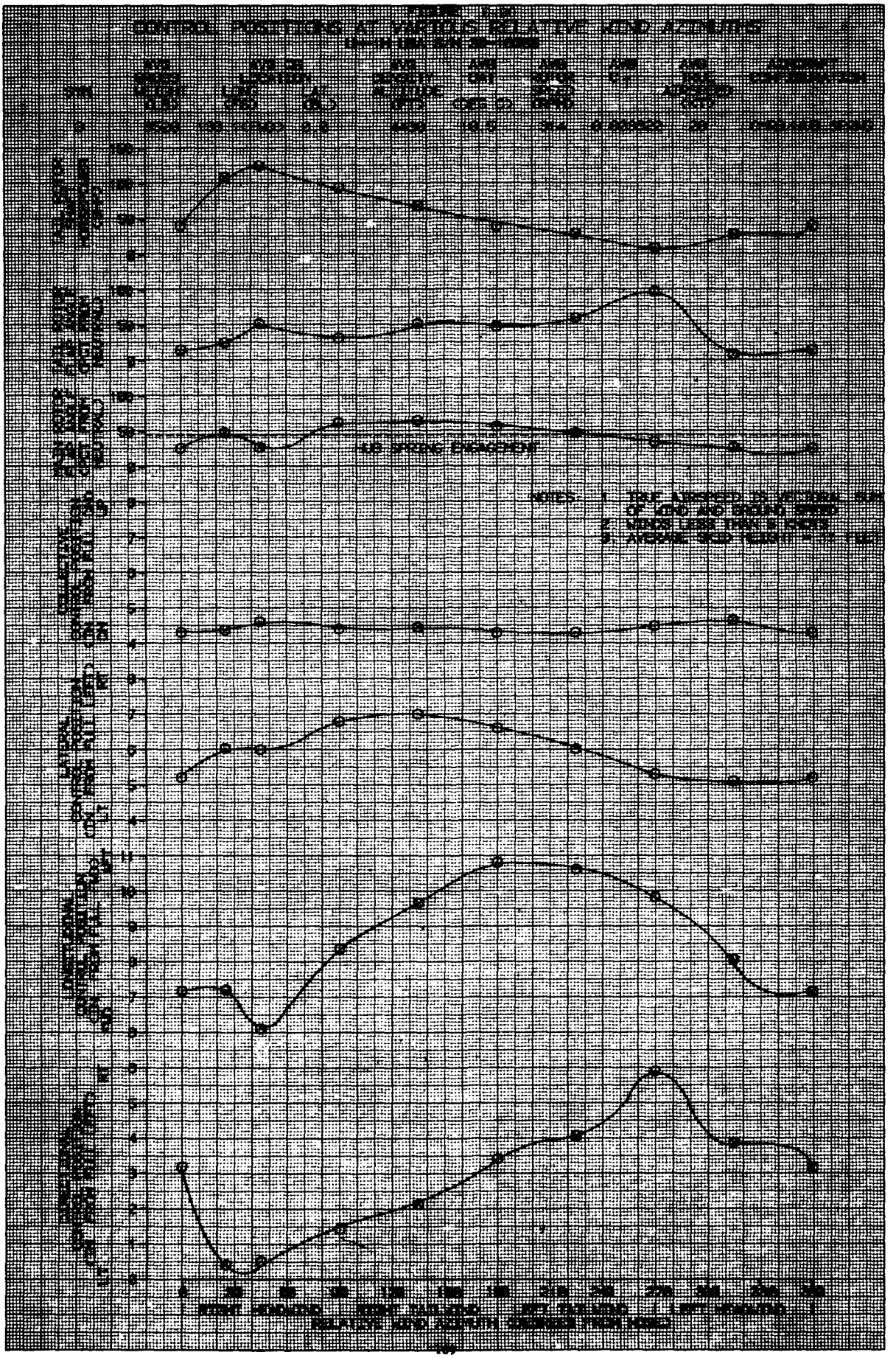
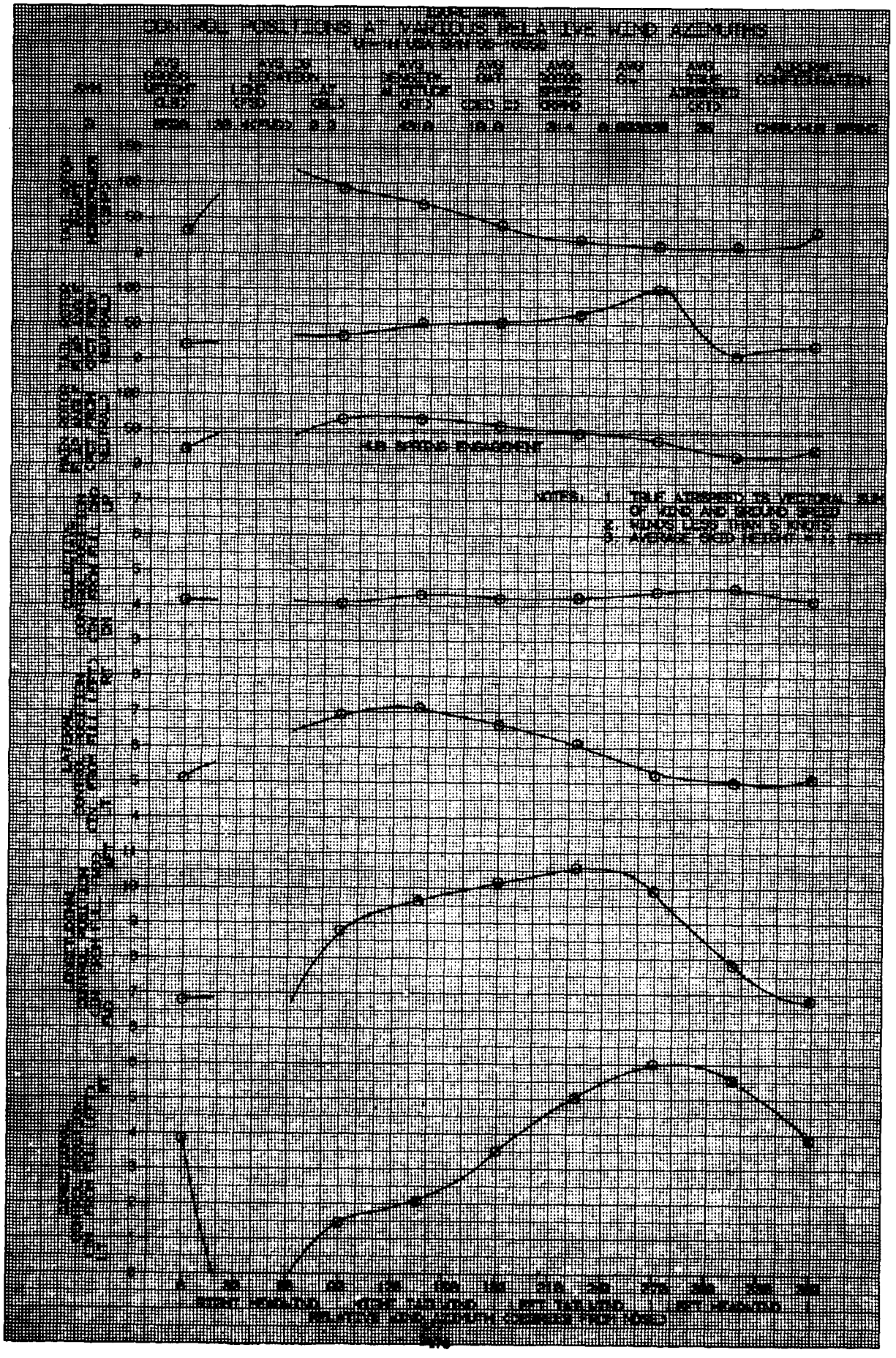

HUB SPRING ENGAGEMENT
NOTES 1. TRUE AIRSPEED IS VECTORIAL SUM OF WIND AND GROUND SPEED
2 WINDS LESS THAN 5 KNOTS
3 AVERAGE SKID HEIGHT = 12 FEET
RIGHT HEADWIND
RIGHT TAILWIND
LEFT TAILWIND
LEFT HEADWIND
RELATIVE WIND AZIMUTH (DEGREES FROM NOSE)

FIGURE X-18

CONTROL POSITIONS AT VARIOUS RELATIVE WIND AZIMUTHS




CONTROL POSITIONS AT VARIOUS RELATIVE WIND AZIMUTHS
NOTES: 1. TRIM ADJUSTED TO VARIOUS RPM OF LOAD AND GROUP SPEED
2. WINDS LESS THAN 5 KNOTS
3. AVERAGE SKID HEIGHT = 4 FEET
HELICOPTER EXCEEDS VNE
RELATIVE WIND AZIMUTH, DEGREES FROM NOSE



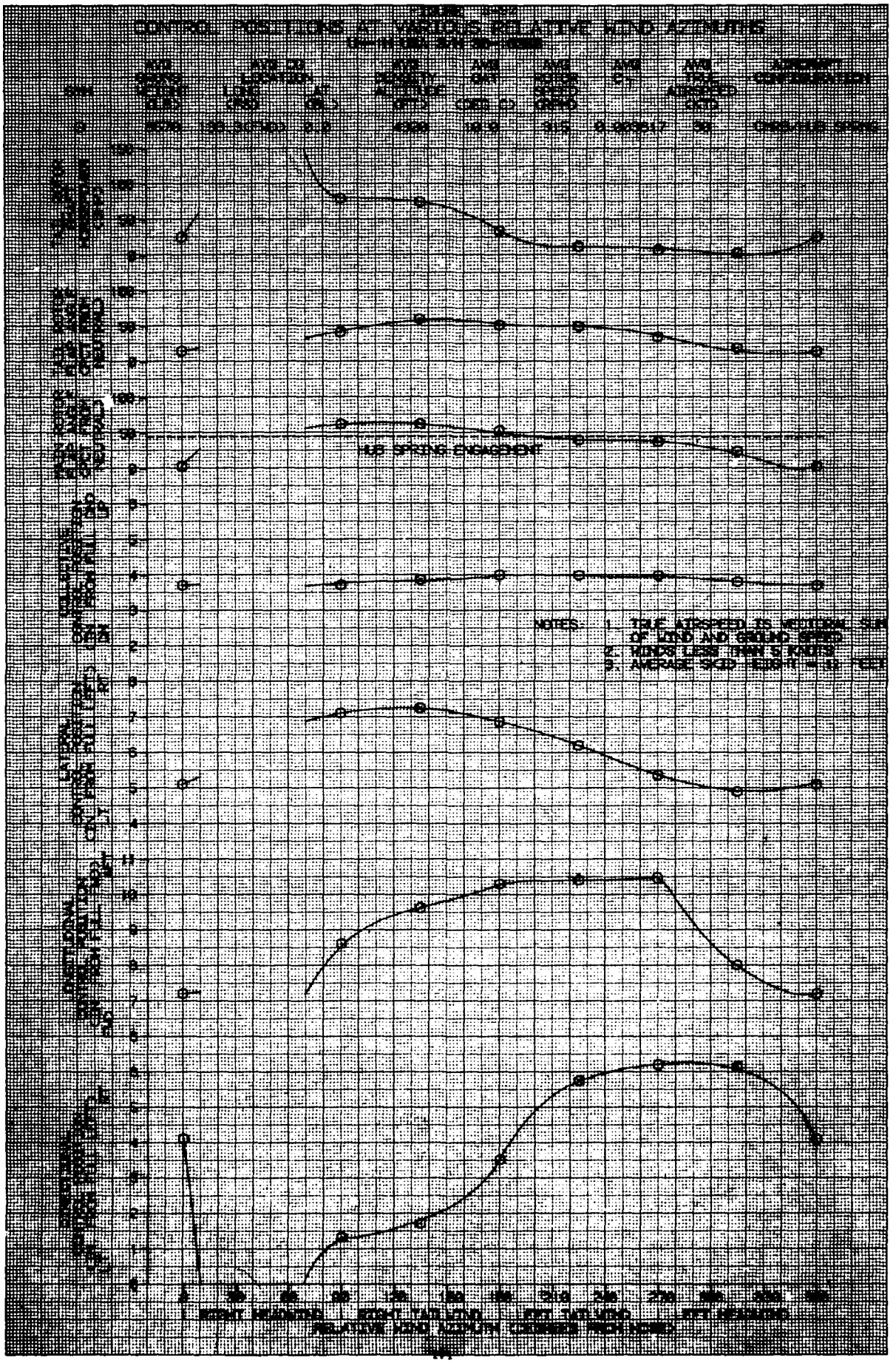
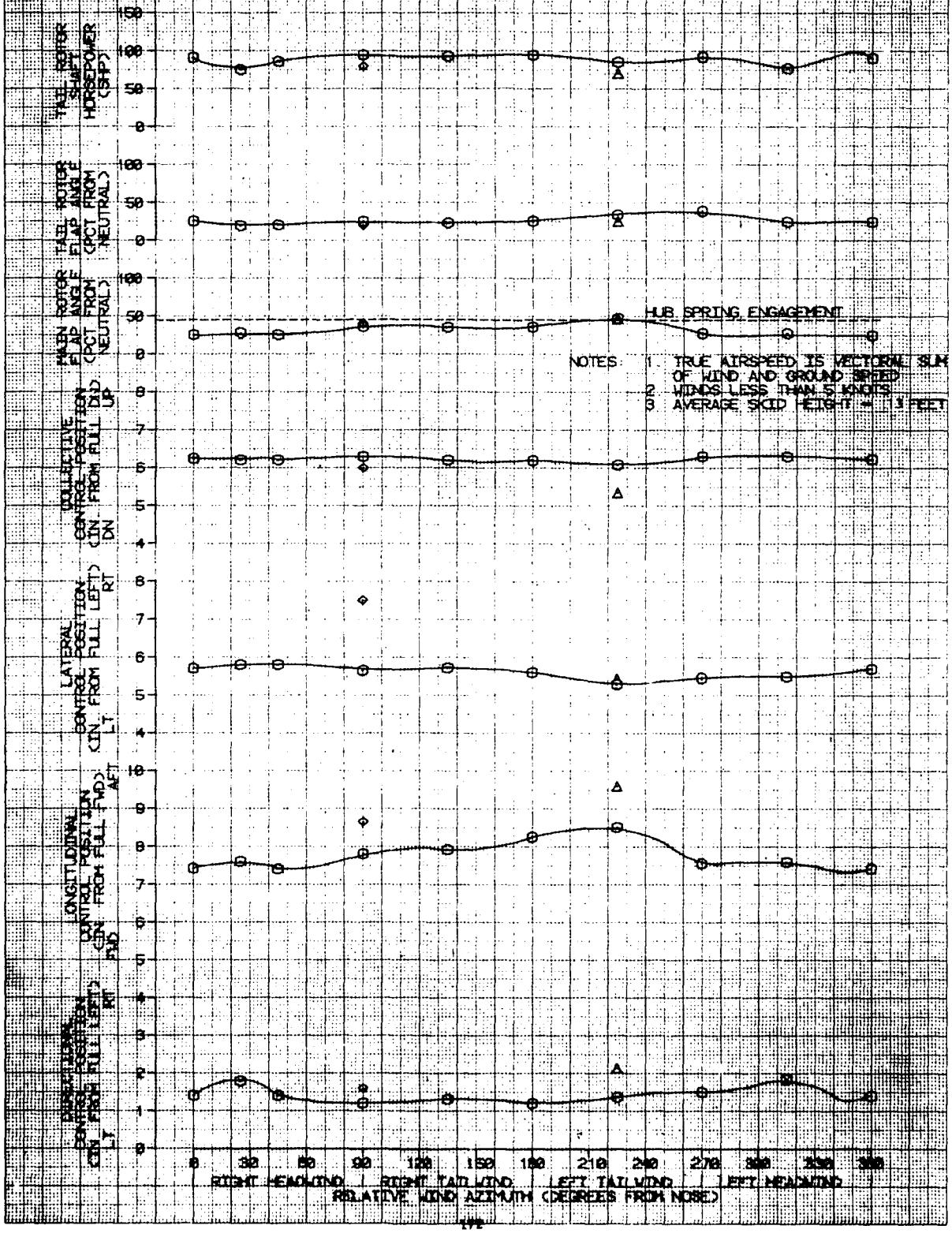

CONTROL POSITIONS AT VARIOUS RELATIVE WIND AZIMUTHS
HUB SPRING ENGAGEMENT
NOTES: 1. TRUE AIRSPEED IS VECTORIAL SUM OF WIND AND GROUND SPEED
2. WINDS LESS THAN 5 KNOTS
3. AVERAGE SKID HEIGHT = 10 FEET
RELATIVE WIND AZIMUTH (DEGREES FROM NOSE)

FIGURE 2-40

CONTROL POSITIONS AT VARIOUS RELATIVE WIND AZIMUTHS

UH-1H USA S/N 66-16558

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	AVG C_T	AVG TRUE AIRSPEED (KT)	AIRCRAFT CONFIGURATION
○	8460	133.8(FWD)	2.0	12550	4.0	313	0.004364	5	CARGO/HUB SPRUNG
△	8650	131.8(FWD)	2.0	12010	6.5	324	0.003907	5	CARGO/HUB SPRUNG
◇	8190	132.5(FWD)	2.9 LT	12020	6.5	314	0.004222	5	CARGO/HUB SPRUNG



NOTES:
1. TRUE AIRSPEED IS VECTORIAL SUM OF WIND AND GROUND SPEED
2. WINDS LESS THAN 5 KNOTS
3. AVERAGE SKID HEIGHT = 13 FEET

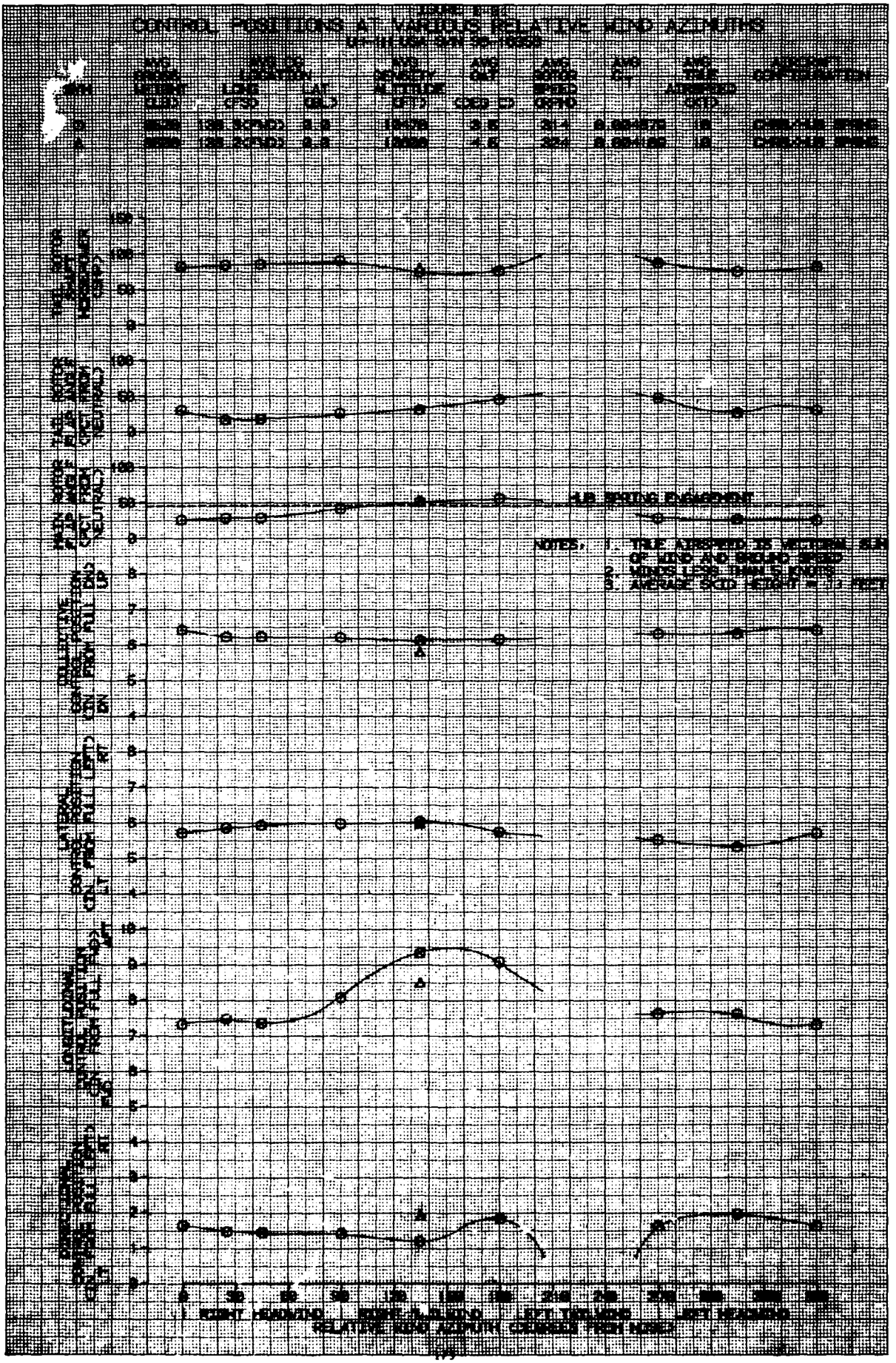
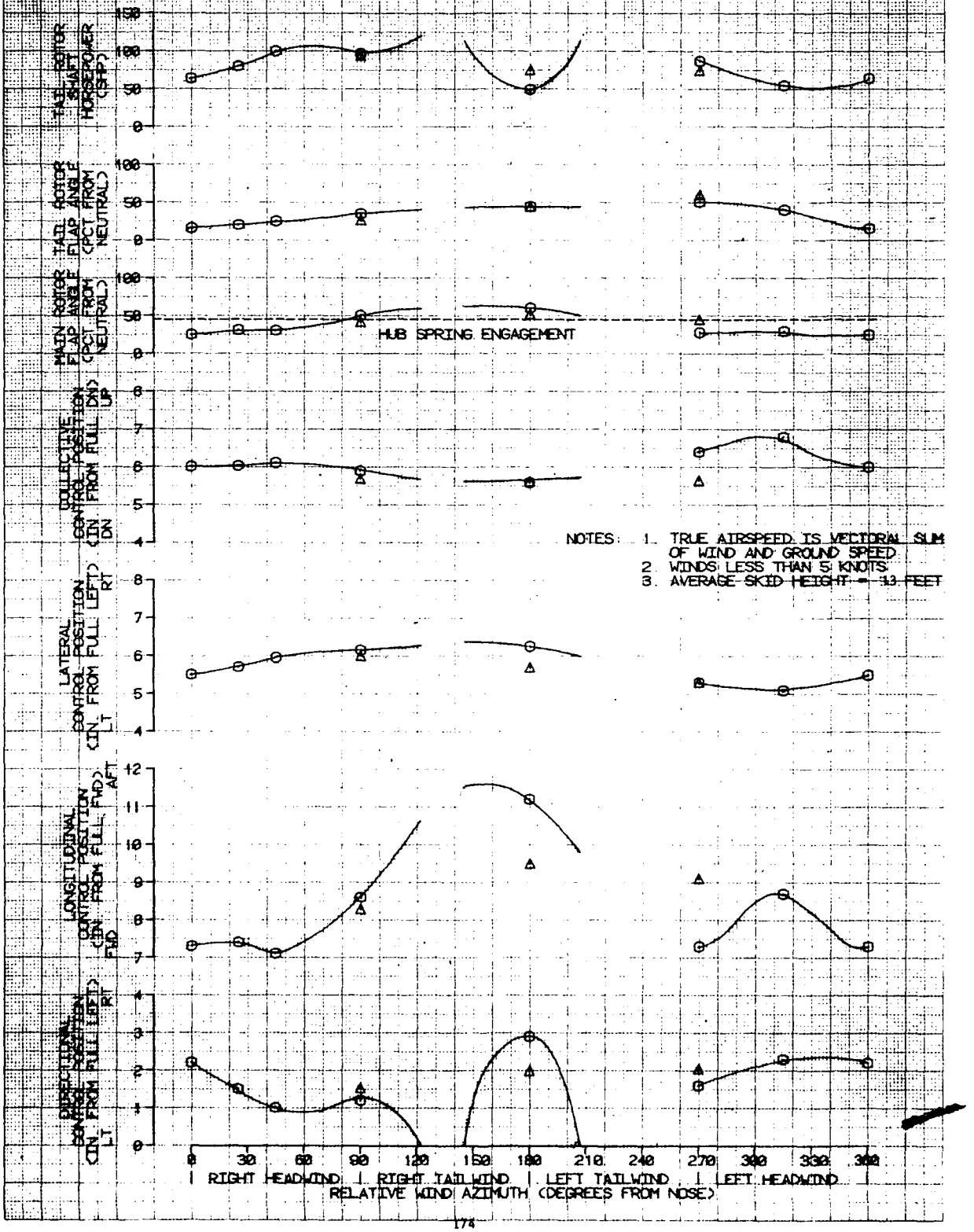

CONTROL POSITIONS AT VARIOUS RELATIVE WIND AZIMUTHS
HUB BEING ENGAGED
NOTES, 1. TRUE AIRSPEED 35 VECTORIAL SUM OF WIND AND ENGINE SPEED
2. WINDS LESS THAN 5 KNOTS
3. AVERAGE SKID HEIGHT = 1½ FEET
RELATIVE WIND AZIMUTH DEGREES FROM NOSE

FIGURE 4-95

CONTROL POSITIONS AT VARIOUS RELATIVE WIND AZIMUTHS

UH-1H USA S/N 66-16558

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	AVG C_T	AVG TRUE AIRSPEED (KT)	AIRCRAFT CONFIGURATION
○	8480	133.1 (FWD)	0.0	10510	3.5	315	0.004326	15	CH13A/HUB SPRNG
△	8370	132.7 (FWD)	0.0	10500	4.0	324	0.004048	15	CH13A/HUB SPRNG



NOTES:
1. TRUE AIRSPEED IS VECTORAL SUM OF WIND AND GROUND SPEED.
2. WINDS LESS THAN 5 KNOTS.
3. AVERAGE SKID HEIGHT = 13 FEET

FIGURE F-24

CONTROL POSITIONS AT VARIOUS RELATIVE WIND AZIMUTHS

UH-1H 68th SAR 66-16558

SYM	AVG GROSS WEIGHT (LBS)	AVG CG LOCATION LONG (FSTA)	LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	AVG C_T	AVG TRUE AIRSPEED (KTS)	AIRCRAFT CONFIGURATION
○	8500	139.2 (FWD)	0.0	12400	3.5	314	0.0064247	20	CARGO/AUX TANK

MAIN ROTOR TAIL ROTOR BLADE ANGLE HORSEPOWER (SHP)

MAIN ROTOR BLADE ANGLE (DEGREES FROM NEUTRAL)

COLLECTIVE CONTROL POSITION (IN FROM FULL DN / UP)

LATERAL CONTROL POSITION (IN FROM FULL LEFT) RT / LT

LONGITUDINAL CONTROL POSITION (IN FROM FULL FWD / AFT) FWD / AFT

HUB SPRING ENGAGEMENT

NOTES:
1. TRUE AIRSPEED IS VECTORIAL SUM OF WIND AND GROUND SPEED
2. WINDS LESS THAN 5 KNOTS
3. AVERAGE SKID HEIGHT = 15 FEET

RIGHT HEADWIND | RIGHT TAILWIND | LEFT TAILWIND | LEFT HEADWIND

RELATIVE WIND AZIMUTH (DEGREES FROM NOSE)

FIGURE 5-97

CONTROL POSITIONS AT VARIOUS RELATIVE WIND AZIMUTHS

UH-1H USN SN# 66-16558

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	AVG C_T	AVG TRUE AIRSPEED (KT)	AIRCRAFT CONFIGURATION
□	8470	138.1 (FWD)	0.0	12440	4.0	315	0.004308	25	[illegible]
△	8420	138.2 (FWD)	0.0	12410	3.0	325	0.004068	25	[illegible]

TAIL ROTOR SHAFT HORSEPOWER (SHP)

TAIL ROTOR FLAP ANGLE (PCT FROM NEUTRAL)

MAIN ROTOR FLAP ANGLE (PCT FROM NEUTRAL)

HUB SPRING ENGAGEMENT

COLLECTIVE CONTROL POSITION (IN FROM FULL DN) UP / DN

LATERAL CONTROL POSITION (IN FROM FULL LEFT) RT / LT

LONGITUDINAL CONTROL POSITION (IN FROM FULL FWD) AFT / FWD

DIRECTIONAL CONTROL POSITION (IN FROM FULL LEFT) RT / LT

NOTES:
1. TRUE AIRSPEED IS VECTORIAL SUM OF WIND AND GROUND SPEED
2. WINDS LESS THAN 5 KNOTS
3. AVERAGE SKID HEIGHT = 11 FEET

0 30 60 90 120 150 180 210 240 270 300 330 360

RIGHT HEADWIND | RIGHT TAILWIND | LEFT TAILWIND | LEFT HEADWIND

RELATIVE WIND AZIMUTH (DEGREES FROM NOSE)

FIGURE B-15

CONTROL POSITIONS AT VARIOUS RELATIVE WIND AZIMUTHS

UH-1H USN SIN 66-16958

RUN	AVG GROSS WEIGHT (LBS)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	AVG TAS (KNOTS)	AVG WIND SPEED (KNOTS)	AIRCRAFT CONFIGURATION
9	9450	138.8(FWD)	9.9	10670	4.8	324	91.8(GND)	20	FWD/AFT CG STICK

NOTES:
1. TRUE AIRSPEED IS VECTORIAL SUM OF WIND AND GROUND SPEED
2. WINDS LESS THAN 5 KNOTS
3. AVERAGE SKID HEIGHT = 14 FEET

HUB SPRING ENGAGEMENT

MAIN ROTOR TAIL ROTOR FLAP ANGLE FLAP ANGLE (PCT FROM NEUTRAL)

COLLECTIVE CONTROL POSITION (IN FROM FULL DN) UP DN

LATERAL CONTROL POSITION (IN FROM FULL LEFT) RT LT

LONGITUDINAL CONTROL POSITION (IN FROM FULL FWD) AFT FWD

DIRECTIONAL CONTROL POSITION (IN FROM FULL LEFT) RT LT

RIGHT HEADWIND | RIGHT TAILWIND | LEFT TAILWIND | LEFT HEADWIND

RELATIVE WIND AZIMUTH (DEGREES FROM NOSE)

FIGURE II-99

LOW SPEED FLIGHT CHARACTERISTICS

UH-1H USA S/N 66-16558

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	AVG SKID HEIGHT (FT)	AIRCRAFT CONFIGURATION
9650	130.5 (FWD)	0.0	740	0.0	315	12	CHINOOK SPRING

NOTES: 1. TRUE AIRSPEED IS VECTORAL SUM OF WIND AND GROUND SPEED.
2. WINDS LESS THAN 5 KNOTS.
3. VERTICAL LINES DENOTE CONTROL AND AIRCRAFT EXCURSIONS.

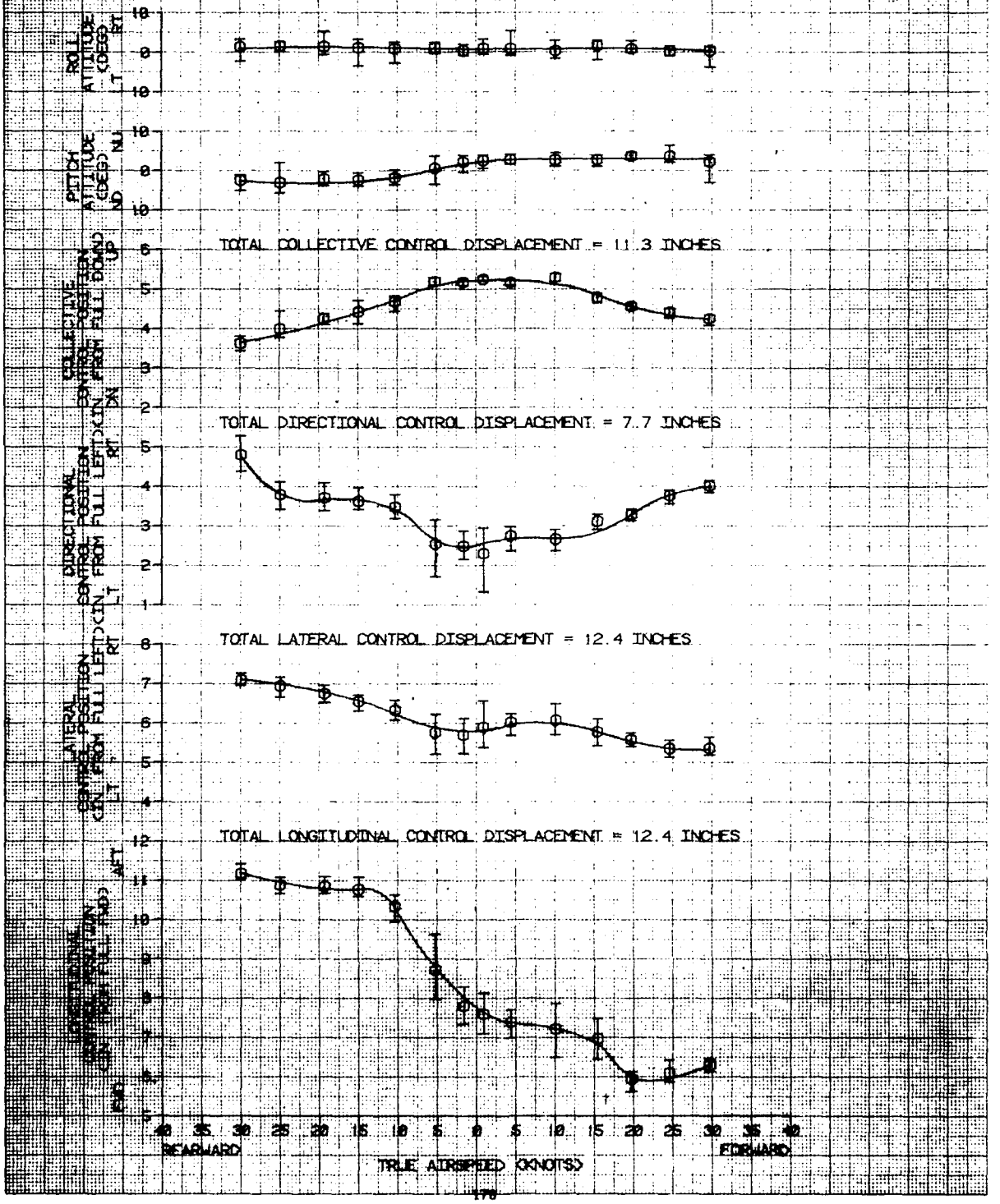


FIGURE 6-100

LOW SPEED FLIGHT CHARACTERISTICS

UH-1H USN BUNO 66-16958

AVG GROSS WEIGHT (LBS)	AVG CG LOCATION LONG (FSS)	LAT (BL)	AVG PRESSURE ALTITUDE (FT)	AMB DAT (DEG C)	AMB ROTOR SPEED (RPM)	AMB SIDE WIND (KTS-DIR)	AIRCRAFT CONFIGURATION
9,85	356.5	0.0	4030	19.0	314	13	EMERGAR BRMS

NOTES: 1. TRUE AIRSPEED IS VECTORIAL SUM OF WIND AND GROUND SPEED
2. WINDS LESS THAN 5 KNOTS
3. VERTICAL LINES DENOTE CONTROL AND AIRCRAFT EXCURSIONS

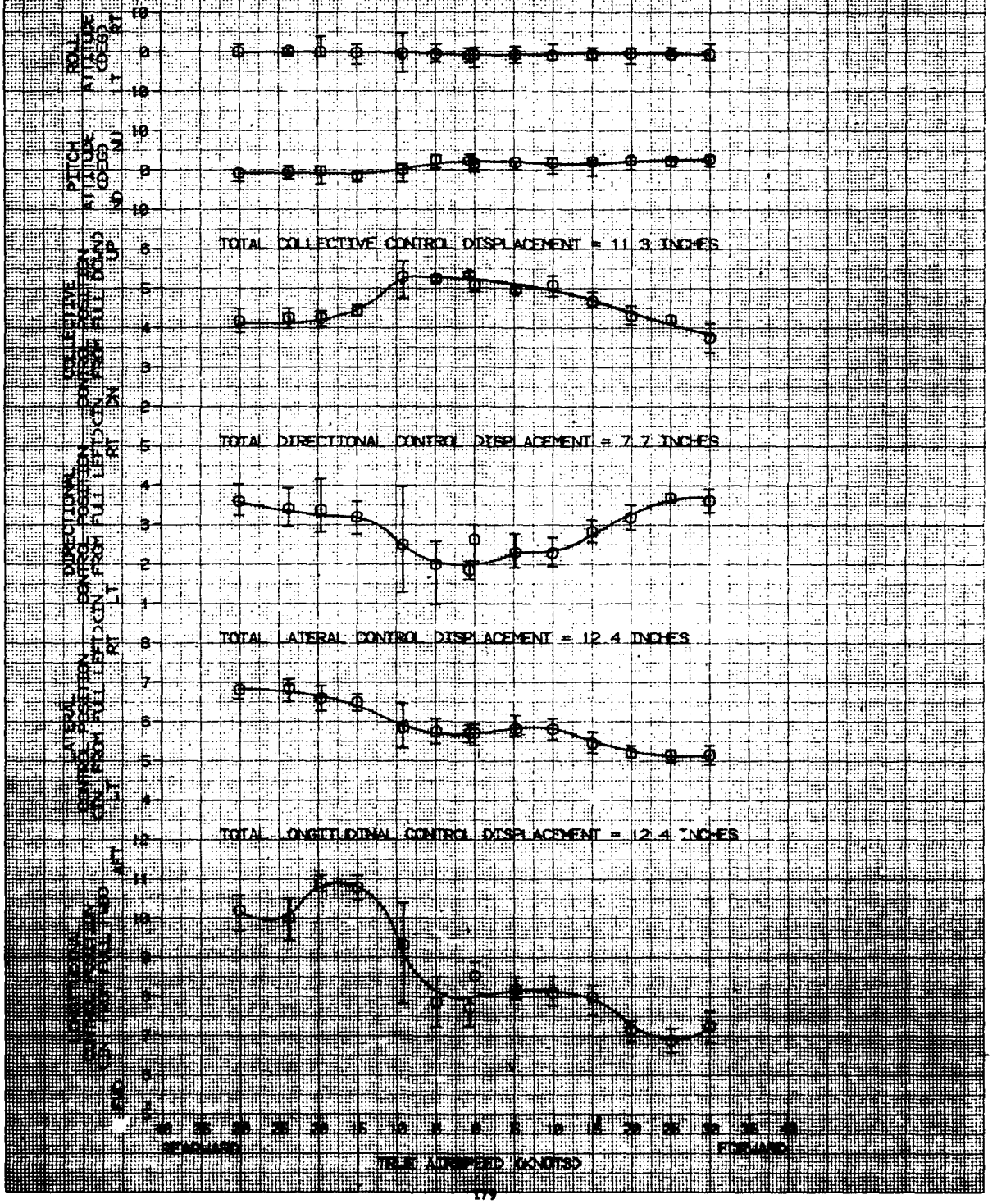


FIGURE 3-110

LOW SPEED FLIGHT CHARACTERISTICS

SIKORSKY S-76 (USA S/N 68-16828)

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FSD)	LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	AVG SKID HEIGHT (FT)	AIRCRAFT CONFIGURATION
8550	198 SCHD	0.0	10000	5.8	314	12	CRUISE FLIGHT

NOTES: 1. TRUE AIRSPEED IS VECTORIAL SUM OF WIND AND GROUND SPEED.
2. WINDS LESS THAN 5 KNOTS.
3. VERTICAL LINES DENOTE CONTROL AND AIRCRAFT EXCURSIONS.

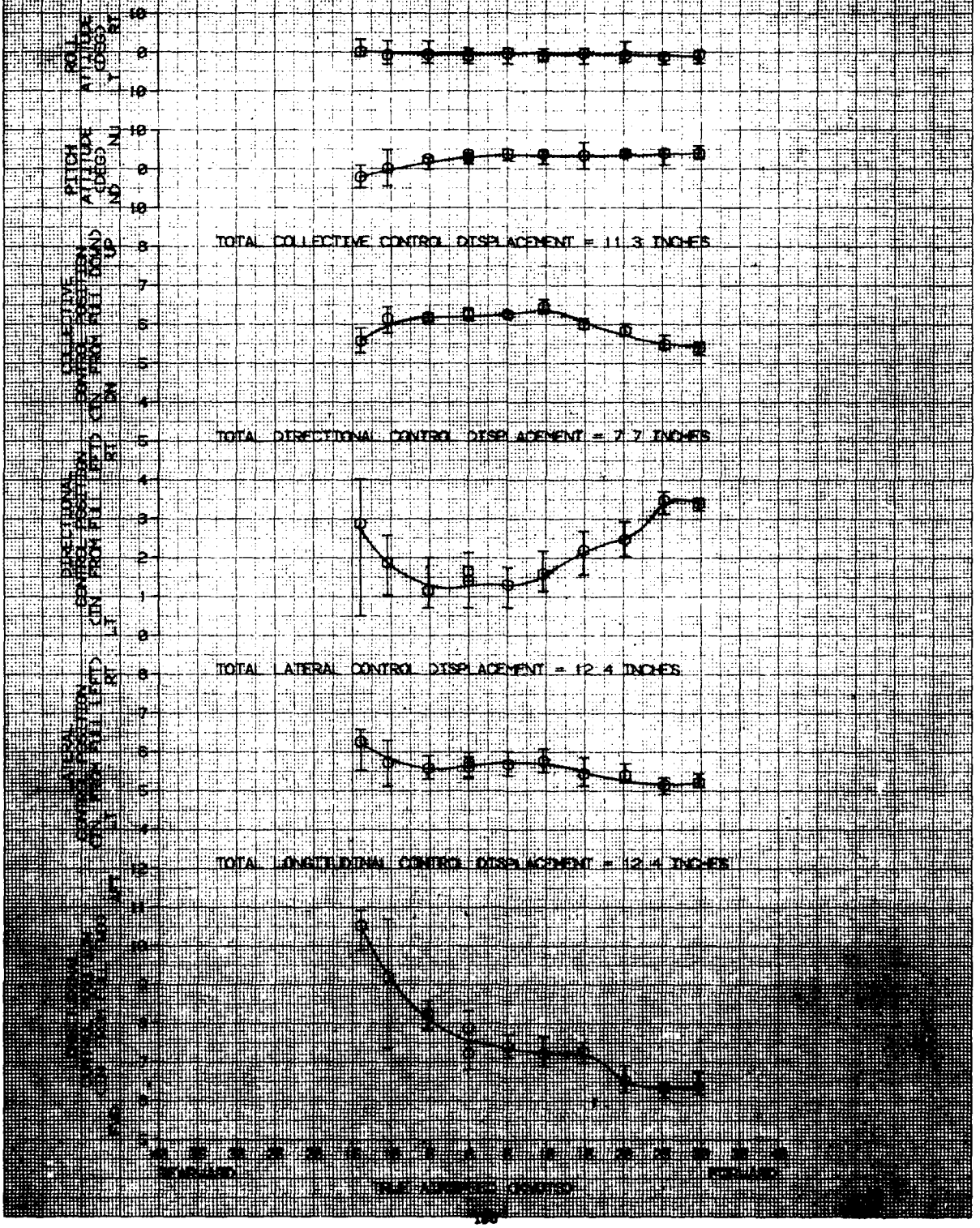


FIGURE E-102

LOW SPEED FLIGHT CHARACTERISTICS

UH-1H USA S/N 66-16556

AVG GROSS WEIGHT (LBS)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AMB OAT (DEG C)	AVG ROTOR SPEED (RPM)	AVG SKID HEIGHT (FT)	AIRCRAFT CONFIGURATION
8820	138.0(CEND)	0.0	740	0.0	3145	13	CRUISE/HUB STRAG

NOTES: 1. TRUE AIRSPEED IS VECTORAL SUM OF WIND AND GROUND SPEED.
2. WINDS LESS THAN 5 KNOTS.
3. VERTICAL LINES DENOTE CONTROL AND AIRCRAFT EXCURSIONS.

ROLL ATTITUDE (DEG) LT RT

PITCH ATTITUDE (DEG) NU ND

TOTAL COLLECTIVE CONTROL DISPLACEMENT = 11.3 INCHES

COLLECTIVE CONTROL POSITION (IN. FROM FULL DOWN) UP DN

TOTAL LONGITUDINAL CONTROL DISPLACEMENT = 12.4 INCHES

LONGITUDINAL CONTROL POSITION (IN. FROM FULL FWD) AFT FWD

TOTAL LATERAL CONTROL DISPLACEMENT = 12.4 INCHES

LATERAL CONTROL POSITION (IN. FROM FULL LEFT) RT LT

TOTAL DIRECTIONAL CONTROL DISPLACEMENT = 7.7 INCHES

DIRECTIONAL CONTROL POSITION (IN. FROM FULL LEFT) RT LT

40 35 30 25 20 15 10 5 0 5 10 15 20 25 30 35 40

LEFT TRUE AIRSPEED (KNOTS) RIGHT

TABLE A-XVII

LOW SPEED FLIGHT CHARACTERISTICS

Q-ITEGA SHIP 69-16359

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	AVG WIND HEIGHT (FT)	AIRCRAFT CONFIGURATION
9650	139.5(FWD)	0.0	4020	10.0	314	13	CHERAUB SPEED

NOTES: 1. TRUE AIRSPEED IS VECTORAL SUM OF WIND AND GROUND SPEED
2. WINDS LESS THAN 5 KNOTS
3. VERTICAL LINES DENOTE CONTROL AND AIRCRAFT EXCURSIONS

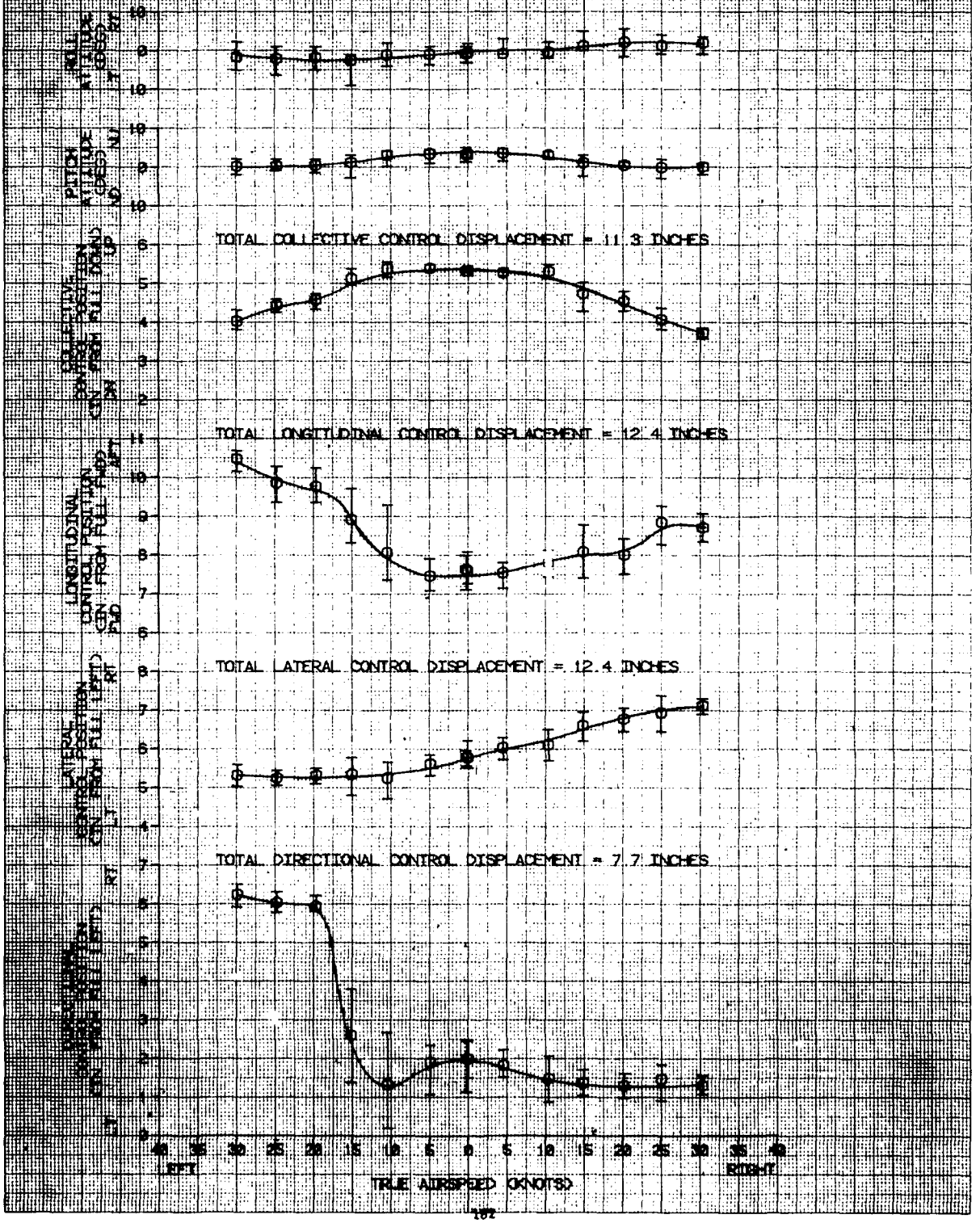


FIGURE X-104

LOW SPEED FLIGHT CHARACTERISTICS

AVG GROSS WEIGHT (LBS)	AVG CG LOCATION LONG (FSS)	LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	AVG SKID HEIGHT (FT)	AIRCRAFT CONFIGURATION
9518	138.3(AFMD)	0.6	10450	5.6	314	12	GW/AAS 2/Std

NOTES: 1. TRUE AIRSPEED IS VECTORIAL SUM OF WIND AND GROUND SPEED.
2. WINDS LESS THAN 5 KNOTS.
3. VERTICAL LINES DENOTE CONTROL AND AIRCRAFT EXCURSIONS.

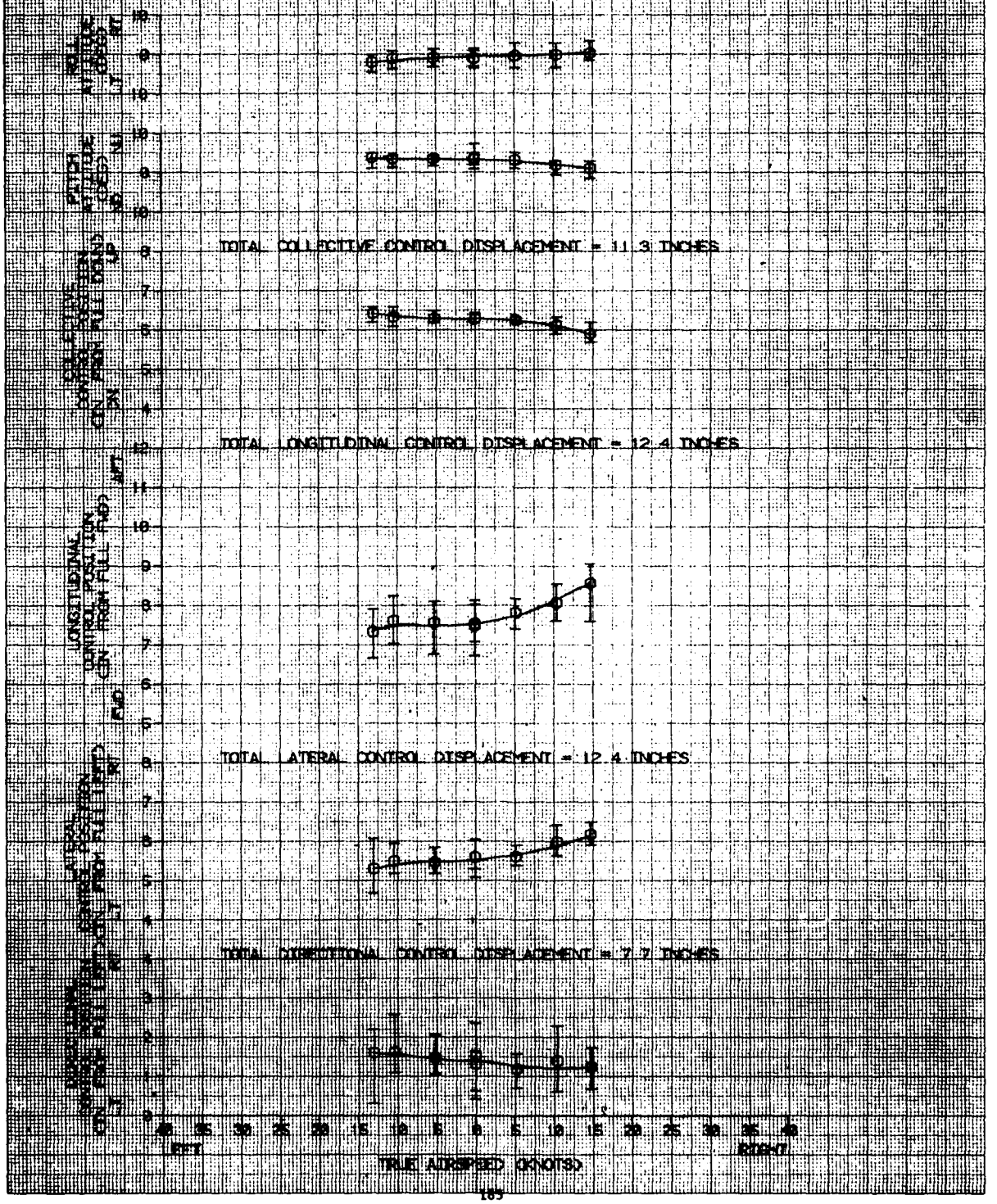


FIGURE E-105A

FORWARD LEVEL ACCELERATION / DECELERATION

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	DENSITY ALTITUDE (FEET)	OAT (DEG C)	ROTOR SPEED (RPM)
8330	132.2(FWD)	0.0	2460	12.0	324

NOTE: CMRB/HUB SPRNG CONFIGURATION

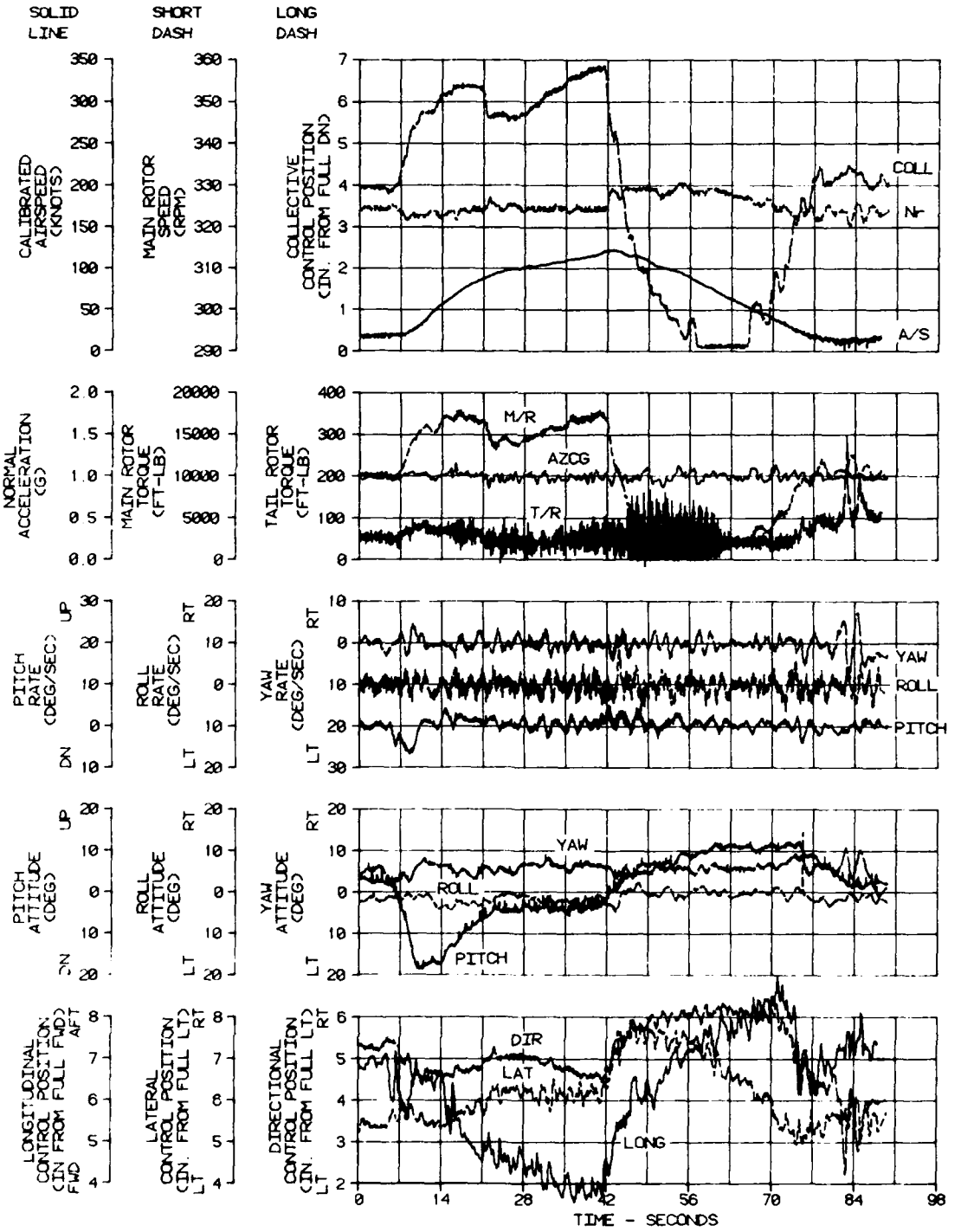


FIGURE E-105B

FORWARD LEVEL ACCELERATION / DECELERATION

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	DENSITY ALTITUDE (FEET)	OAT (DEG C)	ROTOR SPEED (RPM)
8330	132.2(FWD)	0.0	2460	12.0	324

NOTES: 1. CMRB/HUB SPRNG CONFIGURATION
2. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

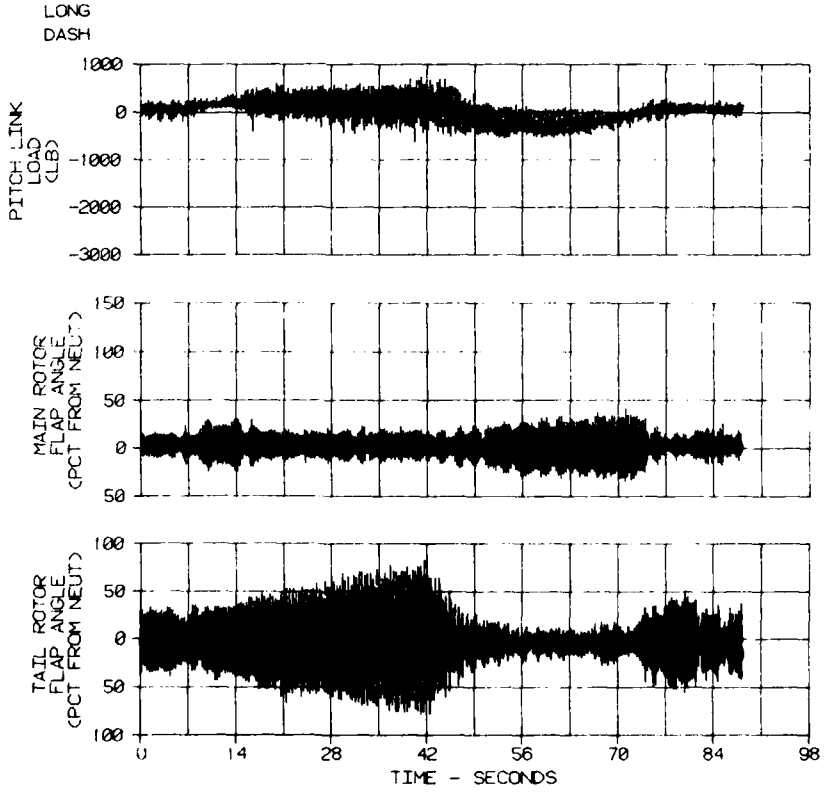


FIGURE B-106A

FORWARD LEVEL ACCELERATION / DECELERATION

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	DENSITY ALTITUDE (FEET)	OAT (DEG C)	ROTOR SPEED (RPM)
8,900	136.3 (FWD)	0.0	2450	12.0	324

NOTE: CMRB/HUB SPRNG CONFIGURATION

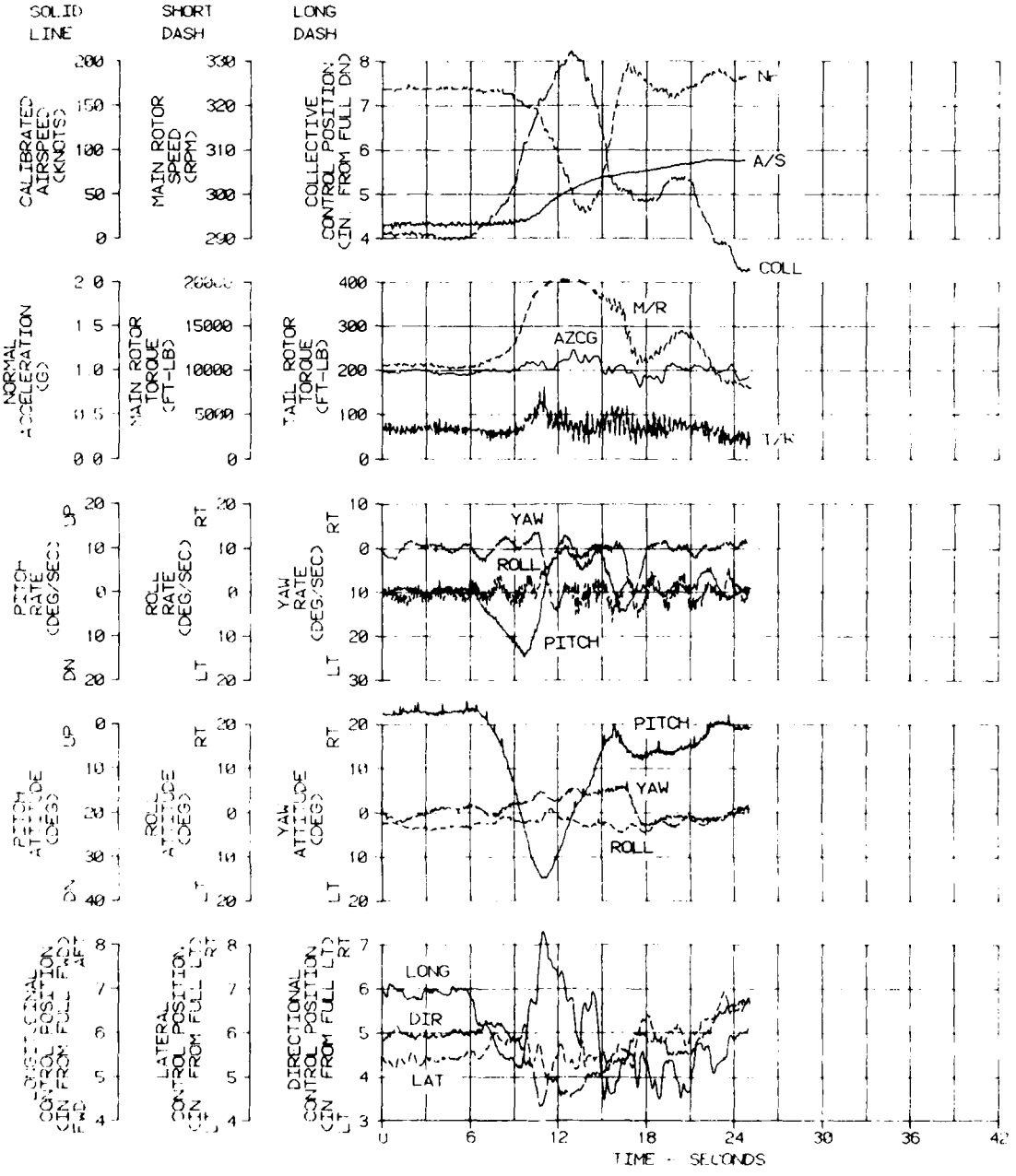


FIGURE E-106B

FORWARD LEVEL ACCELERATION / DECELERATION

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	DENSITY ALTITUDE (FEET)	OAT (DEG C)	ROTOR SPEED (RPM)
8360	132.3(FWD)	0.0	2450	12.0	324

NOTES: 1. CMRB/HUB SPRNG CONFIGURATION
2. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

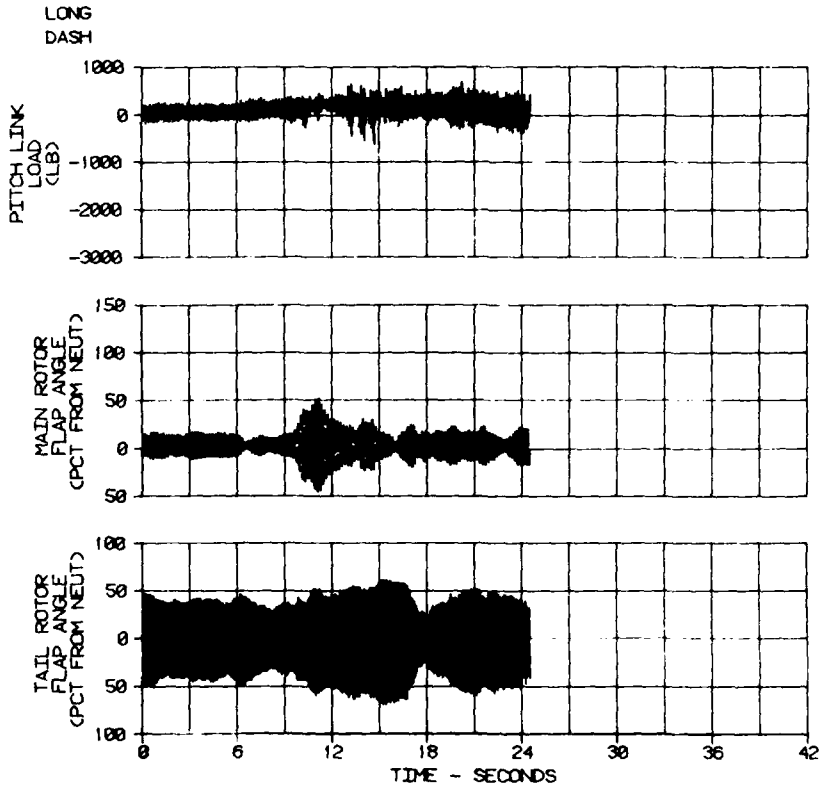


FIGURE E-107A

RIGHT LATERAL ACCELERATION / DECELERATION

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	DENSITY ALTITUDE (FEET)	OAT (DEG C)	ROTOR SPEED (RPM)
7900	131.1(FWD)	0.0	4370	28.5	324

NOTE: CMRB/HUB SPRNG CONFIGURATION

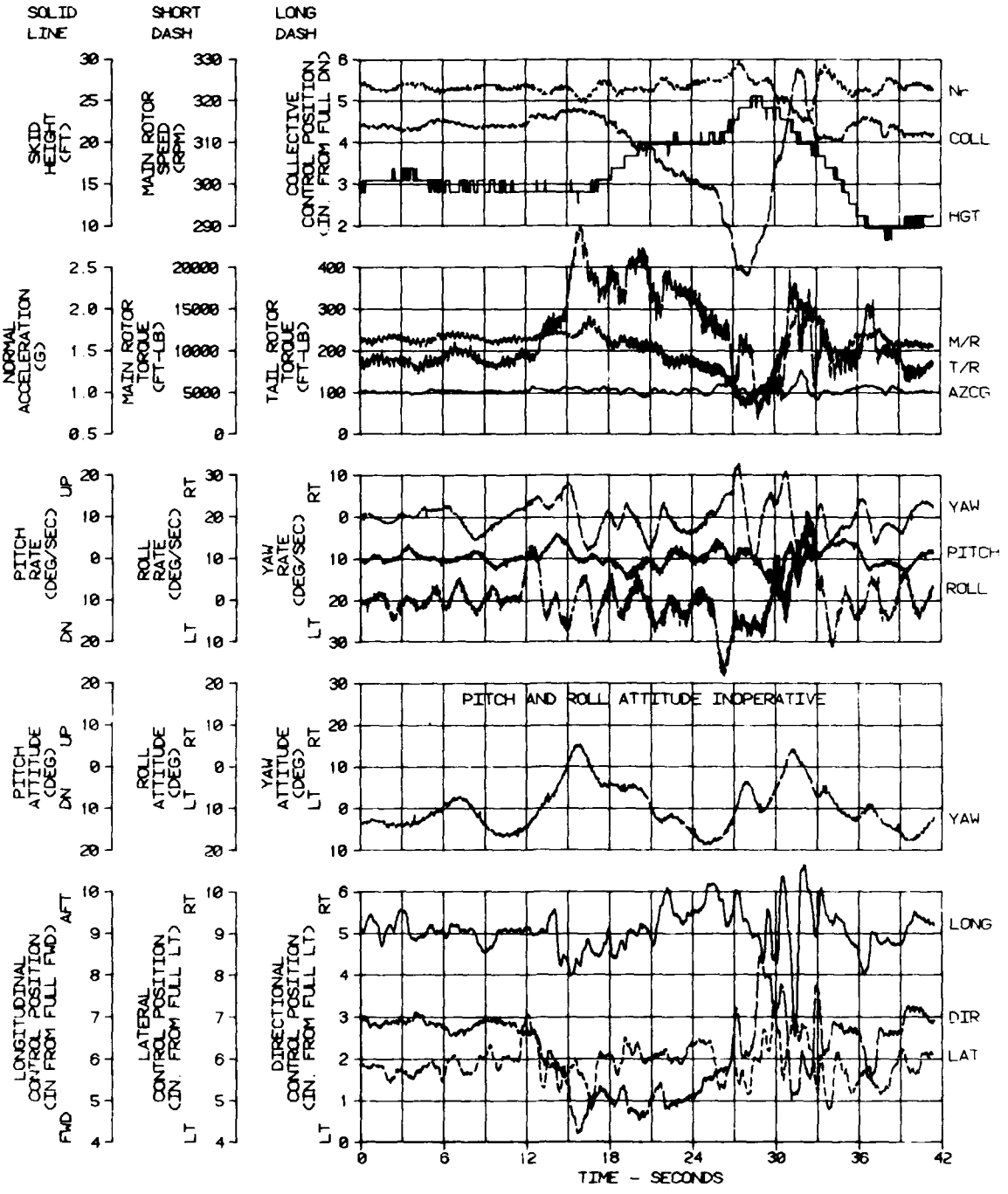


FIGURE E-107B

RIGHT LATERAL ACCELERATION / DECELERATION

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	DENSITY ALTITUDE (FEET)	OAT (DEG C)	ROTOR SPEED (RPM)
7900	131.1(FWD)	0.0	4370	28.5	324

NOTES: 1. CMRB/HUB SPRNG CONFIGURATION
2. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

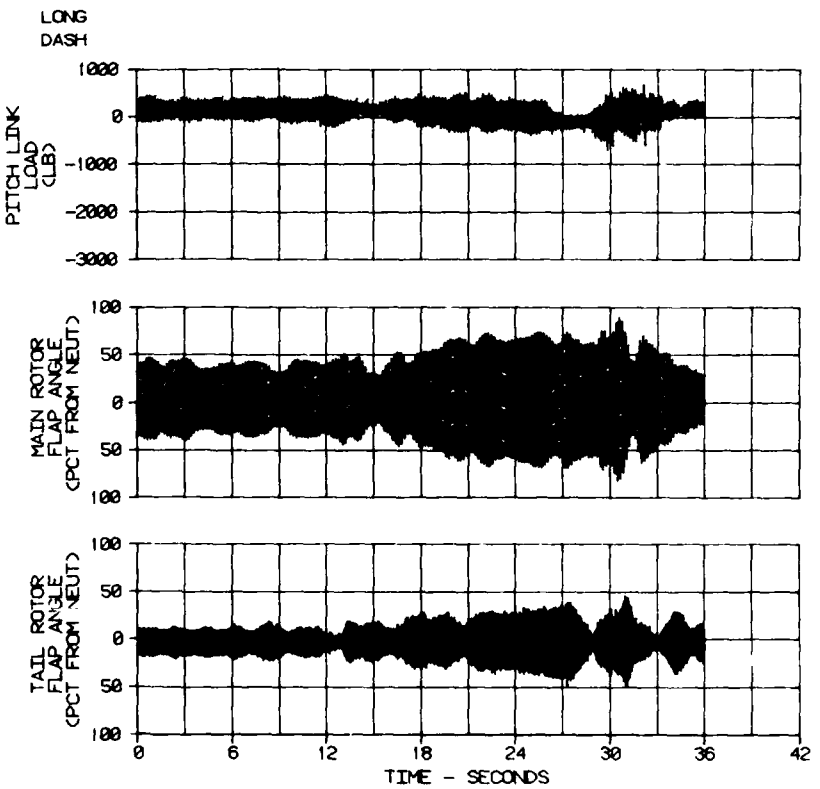


FIGURE E-108A

LEFT LATERAL ACCELERATION / DECELERATION

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	DENSITY ALTITUDE (FEET)	OAT (DEG C)	ROTOR SPEED (RPM)
7800	131.2(FWD)	0.0	4300	29.0	323

NOTE: CMRB/HUB SPRNG CONFIGURATION

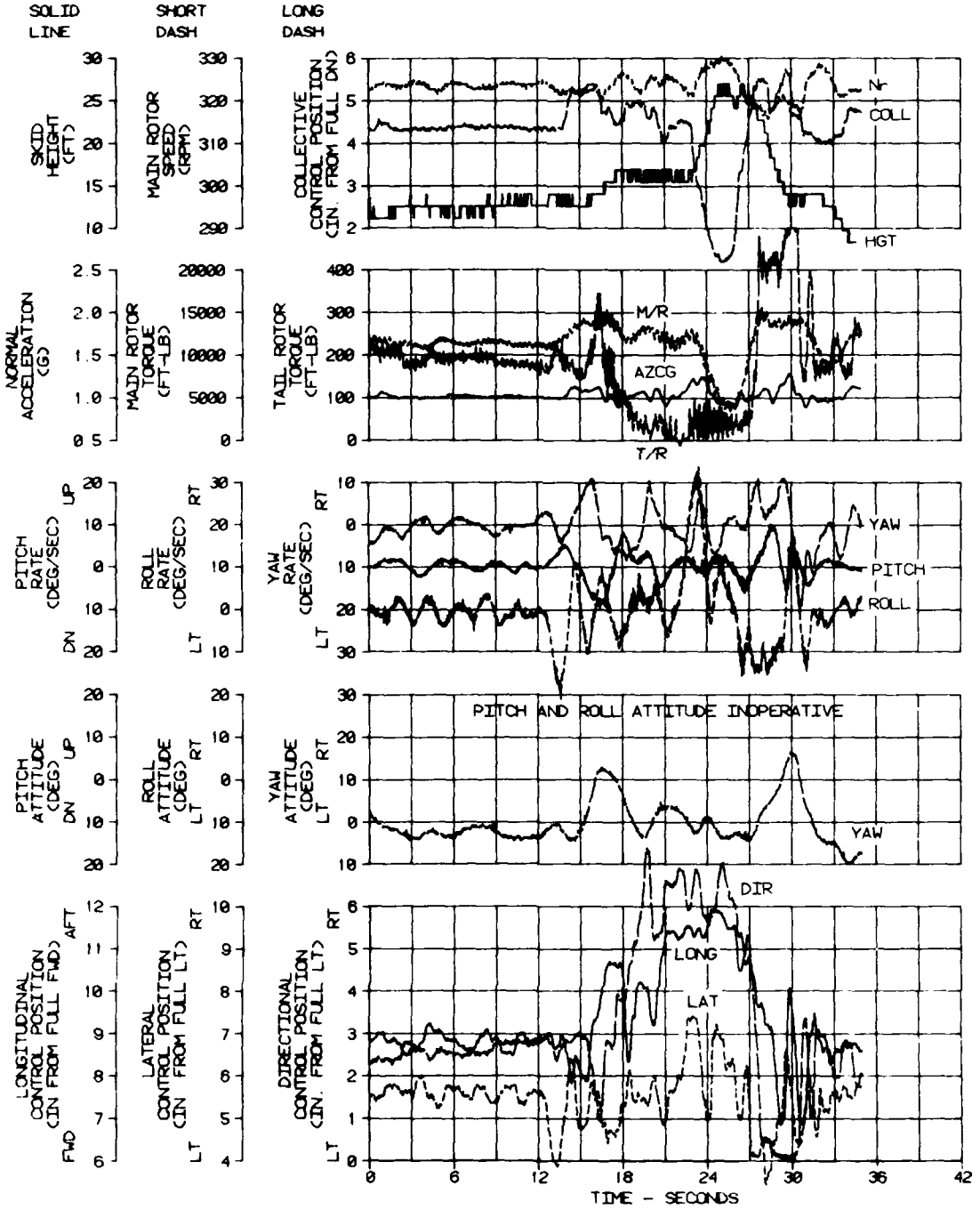


FIGURE E-108B

LEFT LATERAL ACCELERATION / DECELERATION

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	DENSITY ALTITUDE (FEET)	OAT (DEG C)	ROTOR SPEED (RPM)
7880	131.2(FWD)	0.0	4380	29.0	323

NOTES: 1. CMRB/HUB SPRNG CONFIGURATION
2. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

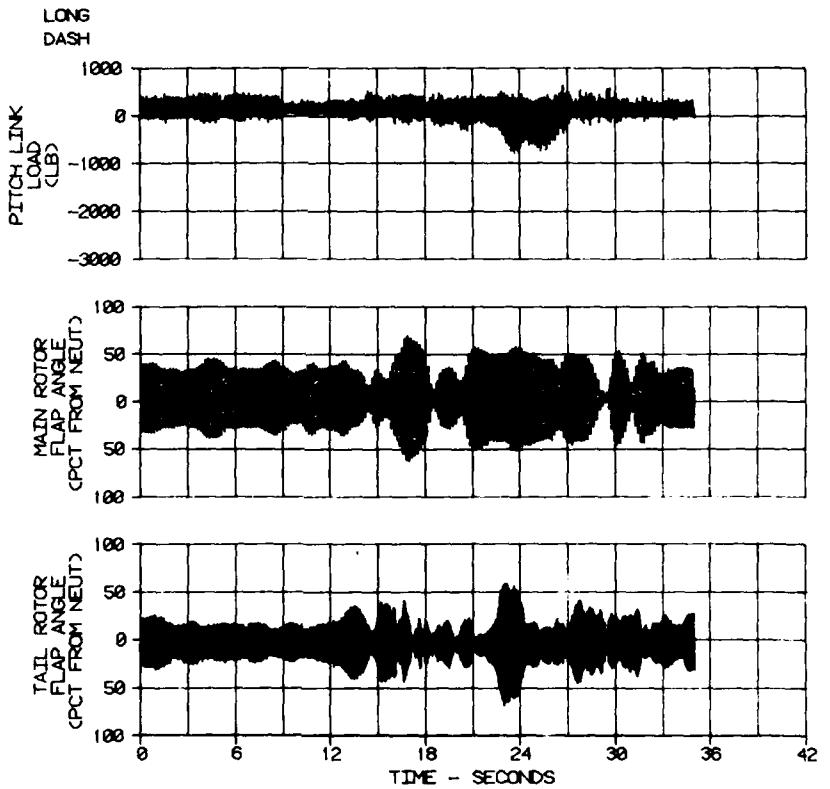


FIGURE E-109A

LEFT LATERAL ACCELERATION / DECELERATION

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	DENSITY ALTITUDE (FEET)	OAT (DEG C)	ROTOR SPEED (RPM)
8550	133.9(FWD)	4.3(LT)	520	0 5	313

NOTE: CMRB/HUB SPRNG CONFIGURATION

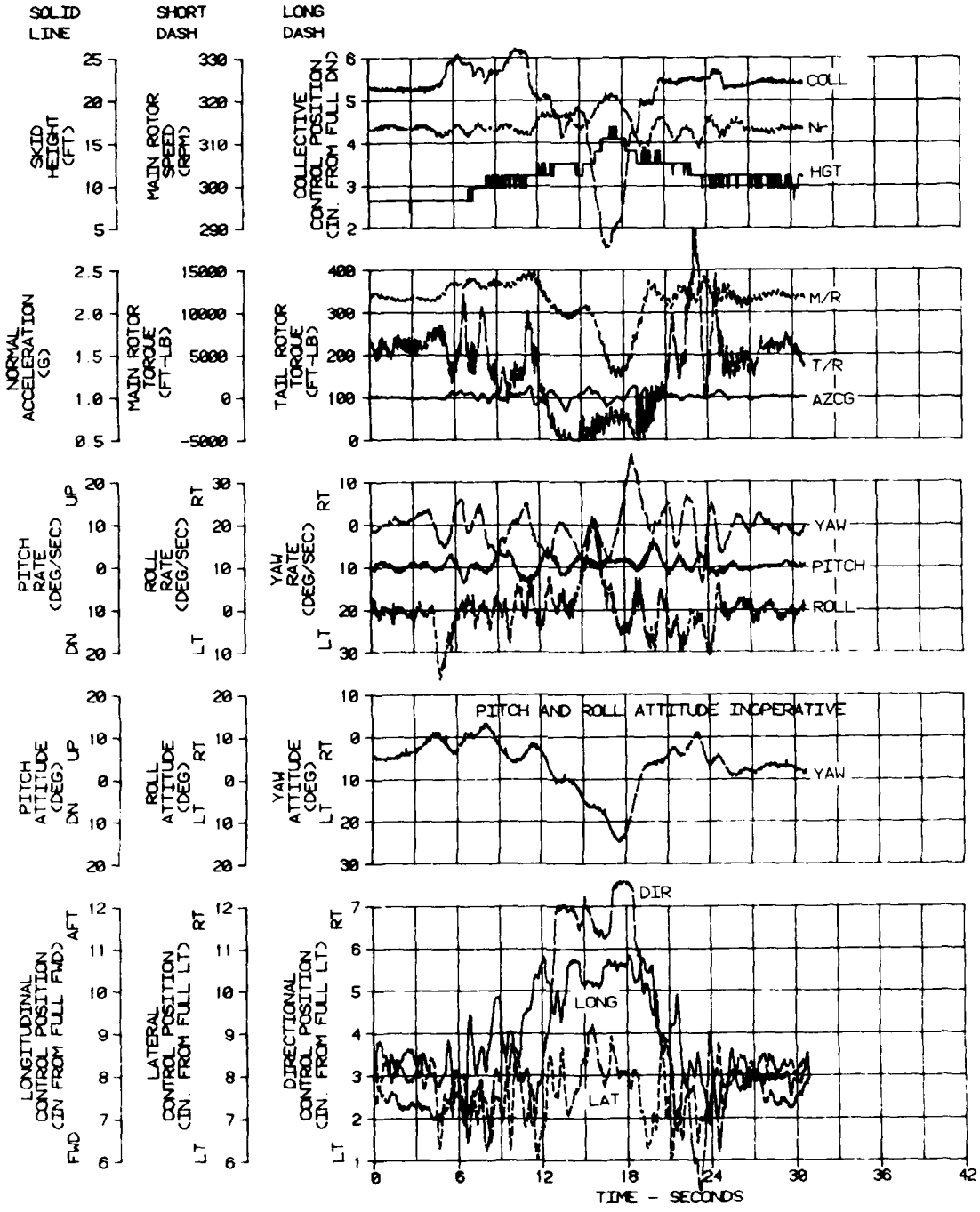


FIGURE E-109B

LEFT LATERAL ACCELERATION / DECELERATION

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	DENSITY ALTITUDE (FEET)	OAT (DEG C)	ROTOR SPEED (RPM)
8550	133.9(FWD)	4.3(LT)	520	0.5	313

NOTES: 1. CMRB/HUB SPRNG CONFIGURATION
2. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

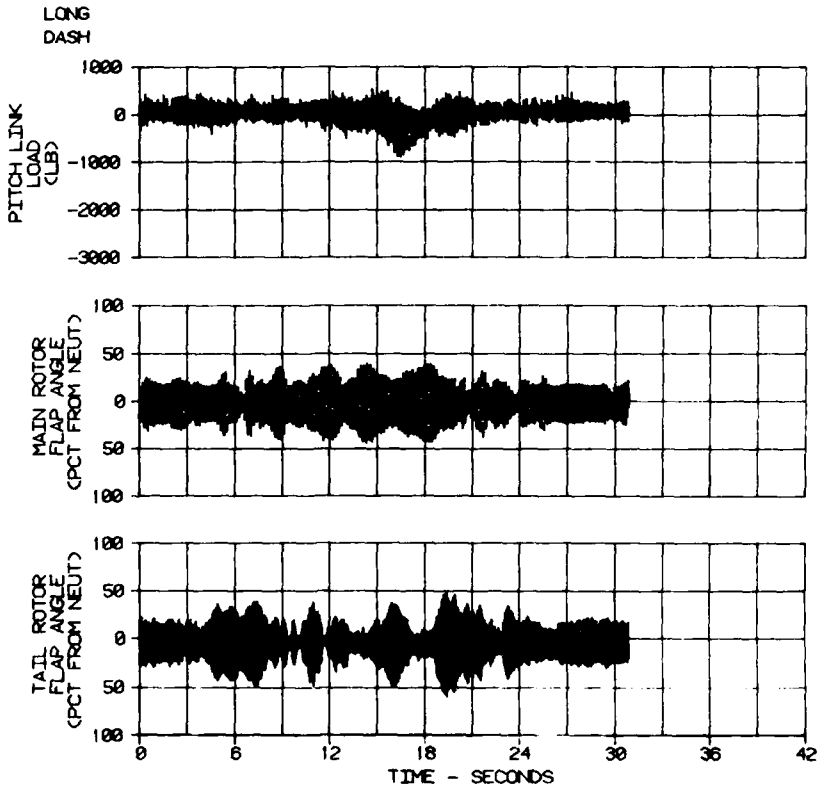


FIGURE E-110

SIMULATED ENGINE FAILURE

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	ENTRY CALIBRATED AIRSPEED (KT)	ENTRY ENGINE TORQUE (PSI)	ENTRY FLIGHT CONDITION
8480	134.0(FWD)	0.0	6150	20.5	106	28.5	LEVEL

NOTES: 1. CMRB/HUB SPRNG CONFIGURATION
2. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

SOLID LINE — SHORT DASH — LONG DASH

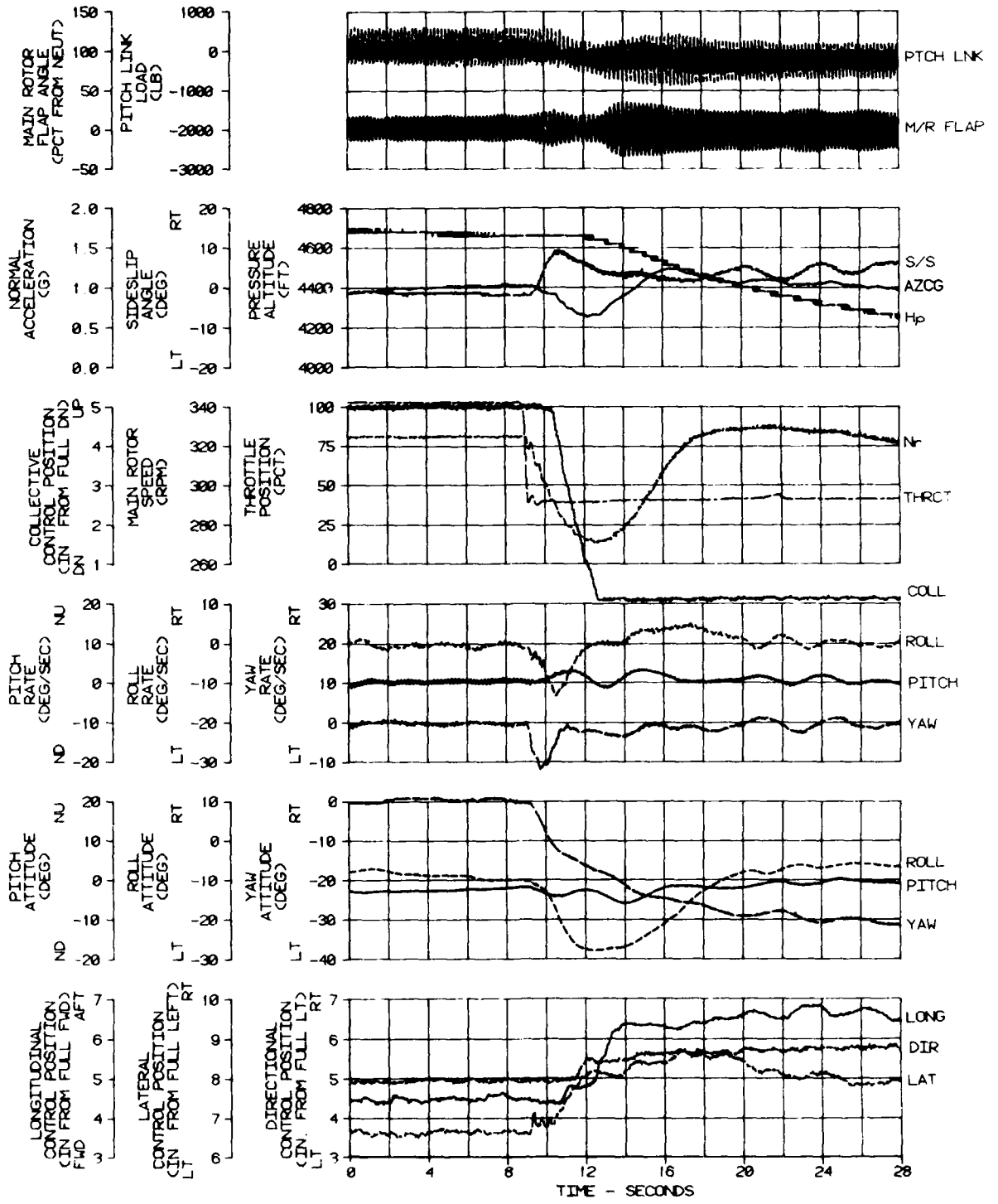


FIGURE E-111

SIMULATED ENGINE FAILURE

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	ENTRY CALIBRATED AIRSPEED (KT)	ENTRY ENGINE TORQUE (PSI)	ENTRY FLIGHT CONDITION
7010	133.0(FWD)	0.0	5900	15.5	116	29.9	LEVEL

NOTES: 1. PROD CMRB/HUB SPRNG CONFIGURATION
2. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

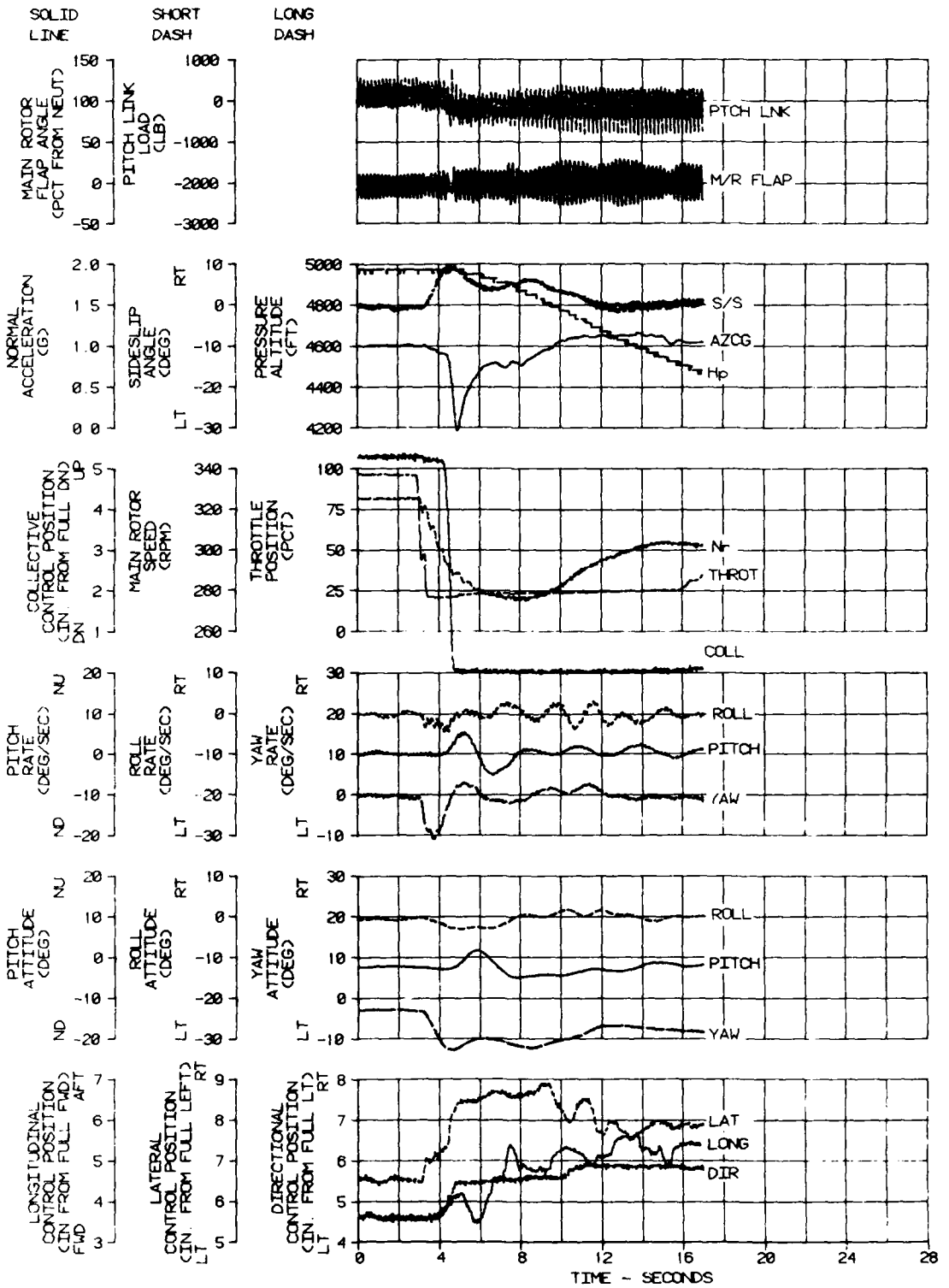


FIGURE E-112

SIMULATED ENGINE FAILURE

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	ENTRY CALIBRATED AIRSPEED (KT)	ENTRY ENGINE TORQUE (PSI)	ENTRY FLIGHT CONDITION
8330	134.0(FWD)	0.0	7970	18.5	59	39.8	MAX PWR CLMB

NOTES: 1. CMRB/HUB SPRNG CONFIGURATION
2. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

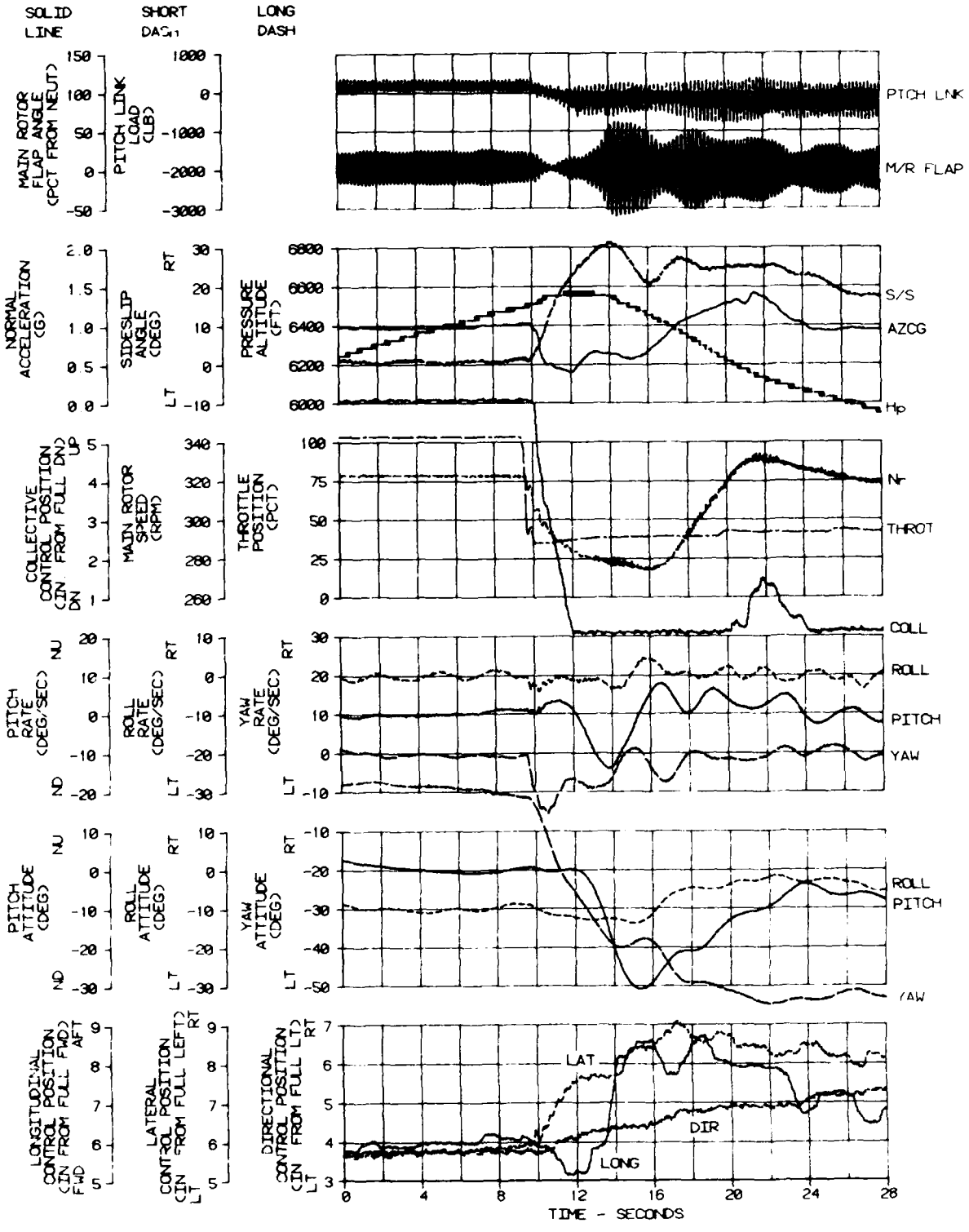


FIGURE E-113

SIMULATED ENGINE FAILURE

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	ENTRY CALIBRATED AIRSPEED (KT)	ENTRY ENGINE TORQUE (PSI)	ENTRY FLIGHT CONDITION
8550	134.0(FWD)	4.0(LT)	6250	16.5	99	28.4	LEVEL

NOTES: 1. CMRB/HUB SPRNG CONFIGURATION
2. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

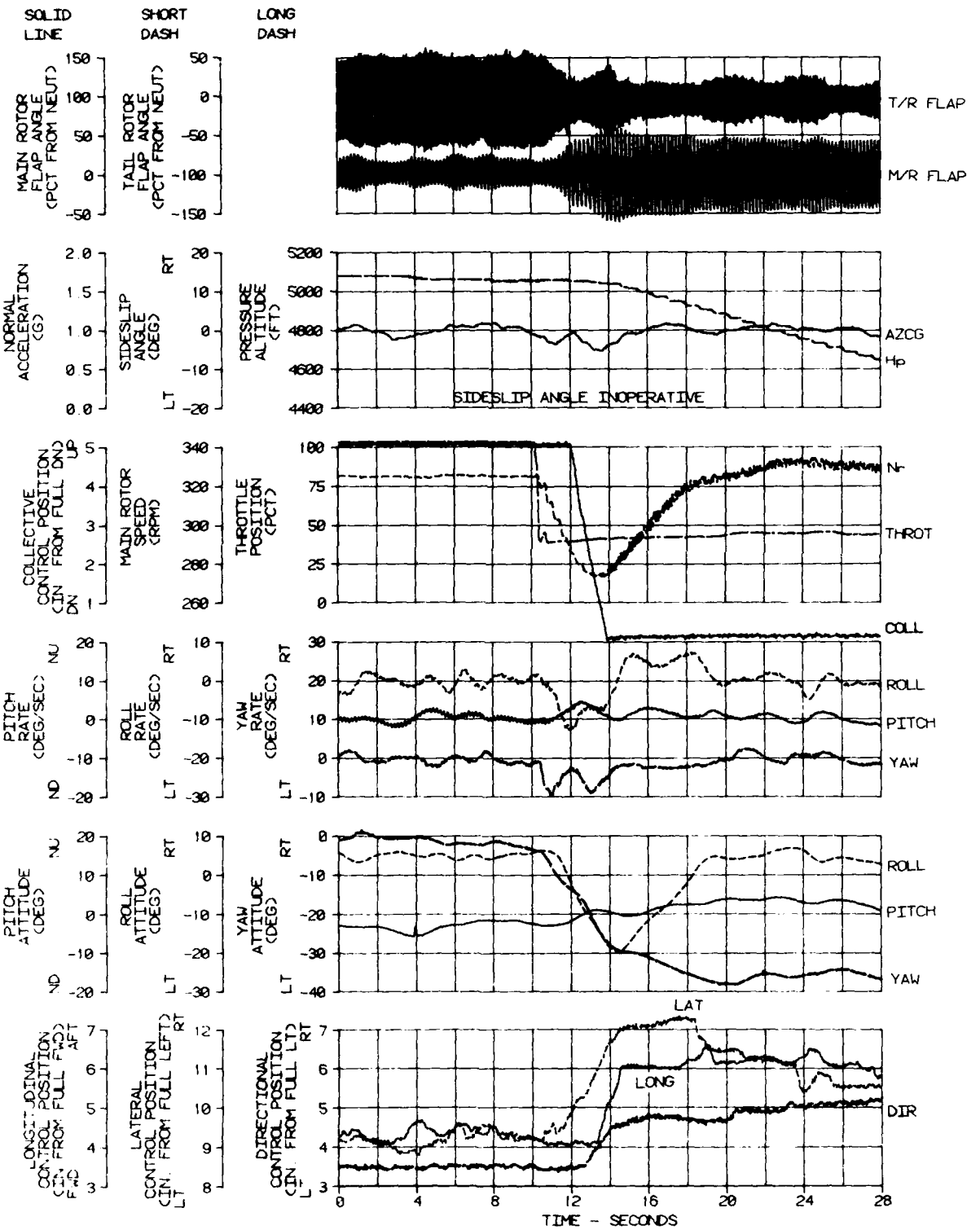


FIGURE 3-12a.

CONTROL ACTIVITY IN TRIMMED FORWARD FLIGHT
UH-1H USA S/N 68-15858

KIAS	AVG GROSS WEIGHT (LBS)	AVG CG LOCATION LONG (FS)	AVG CG LAT (IN)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM (FUSE) CONDITION	HYDRAULIC SERVICE
80	8400	132.2(FWD)	0.0	6000	9.5	321	LEVEL	ON
0	8700	134.8(FWD)	0.0	6240	8.0	326	LEVEL	OFF

NOTES: 1. CHERRY-HUB SPRING CONFIGURATION
2. VERTICAL LINES DENOTE CONTROL AND AIRCRAFT EXCURSIONS

PITCH LINK LOAD (LBS): 1000, 0, 1000

MAIN ROTOR FLAP ANGLE (DEG FROM NEUTRAL): 100, 50, 0

ROLL RATE AND MAIN ROTOR FLAP ANGLE INOPERATIVE FOR HYDRAULICS ON CONDITION

ROLL RATE (DEG/SEC): 10 RT, 0, 10 LT

TOTAL COLLECTIVE CONTROL DISPLACEMENT = 11.3 IN.

COLLECTIVE CONT POSN FROM CEN. (FROM FULL DWN): 7 UP, 6, 5, 4, 3 DN

TOTAL DIRECTIONAL CONTROL DISPLACEMENT = 7.7 IN.

DIRECTIONAL CONT POSN FROM CEN. (FROM FULL LEFT): 6 RT, 5, 4, 3 LT

TOTAL LATERAL CONTROL DISPLACEMENT = 12.4 IN.

LATERAL CONT POSN FROM CEN. (FROM FULL LEFT): 8 RT, 7, 6, 5 LT

TOTAL LONGITUDINAL CONTROL DISPLACEMENT = 12.4 IN.

LONGITUDINAL CONT POSN FROM CEN. (FROM FULL FWD): 8 AFT, 7, 6, 5, 4, 3 FWD

0, 20, 40, 60, 80, 100, 120, 140, 160

CALIBRATED AIRSPEED (KNOTS)

FIGURE E-115A

STRAIGHT APPROACH TO AN AUTOROTATIONAL LANDING

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)
7590	139.8	0.0	3870	18.0	318	99

NOTES: 1. CMRB/HUB SPRNG CONFIGURATION
2. LIMIT LOAD FACTOR = 2.08

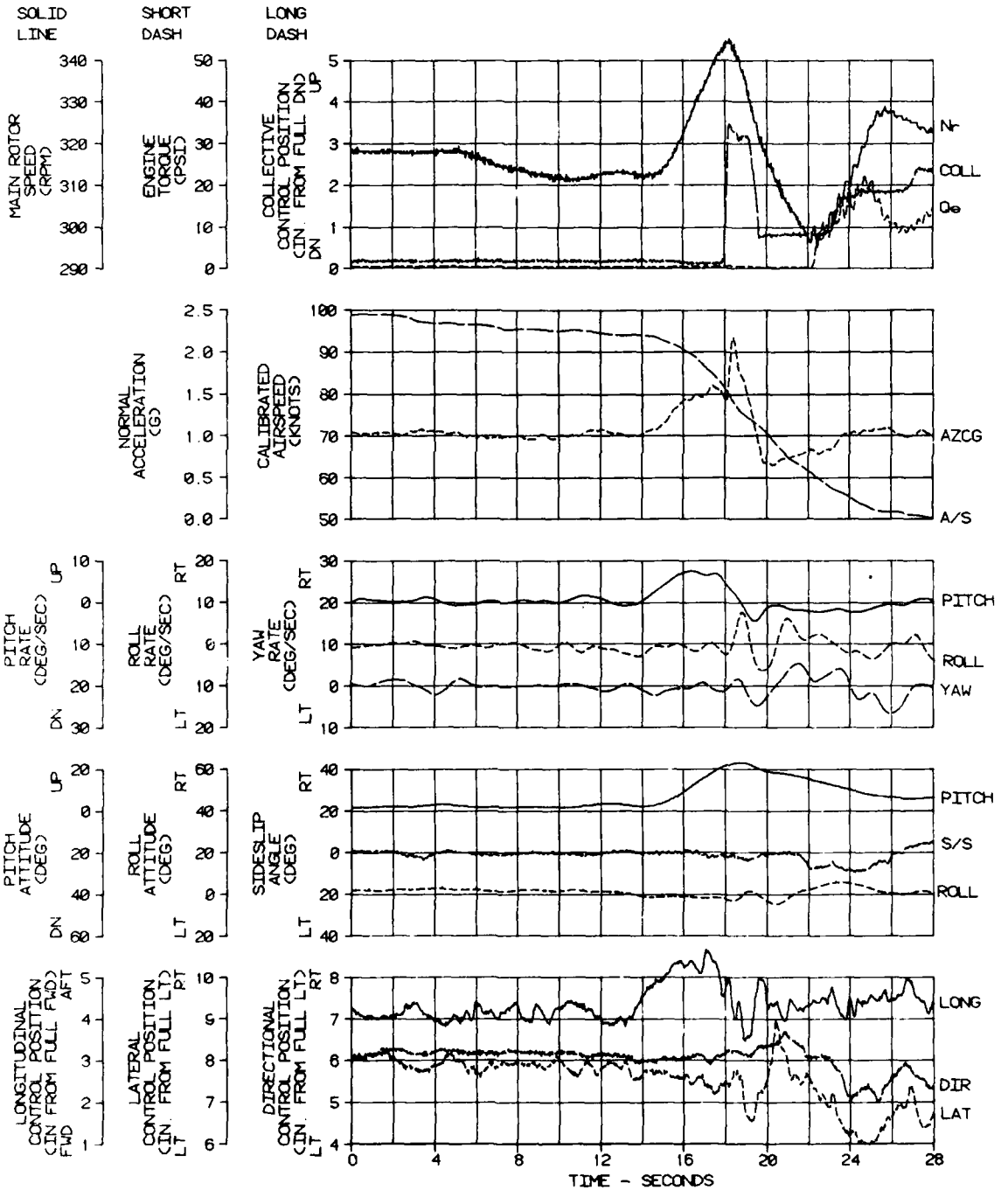


FIGURE E-115B

STRAIGHT APPROACH TO AN AUTOROTATIONAL LANDING

UH-1H USA S/N 68-16358

GROSS WEIGHT	CG LOCATION LONG	CG LOCATION LAT	TRIM DENSITY ALTITUDE	OAT	TRIM ROTOR SPEED	TRIM CALIBRATED AIRSPEED
(LB)	(FS)	(BL)	(FEET)	(DEG C)	(RPM)	(KT)
7500	139.8	0.0	3870	18.0	318	99

NOTES: 1. CMRB/HUB SPRNG CONFIGURATION
2. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

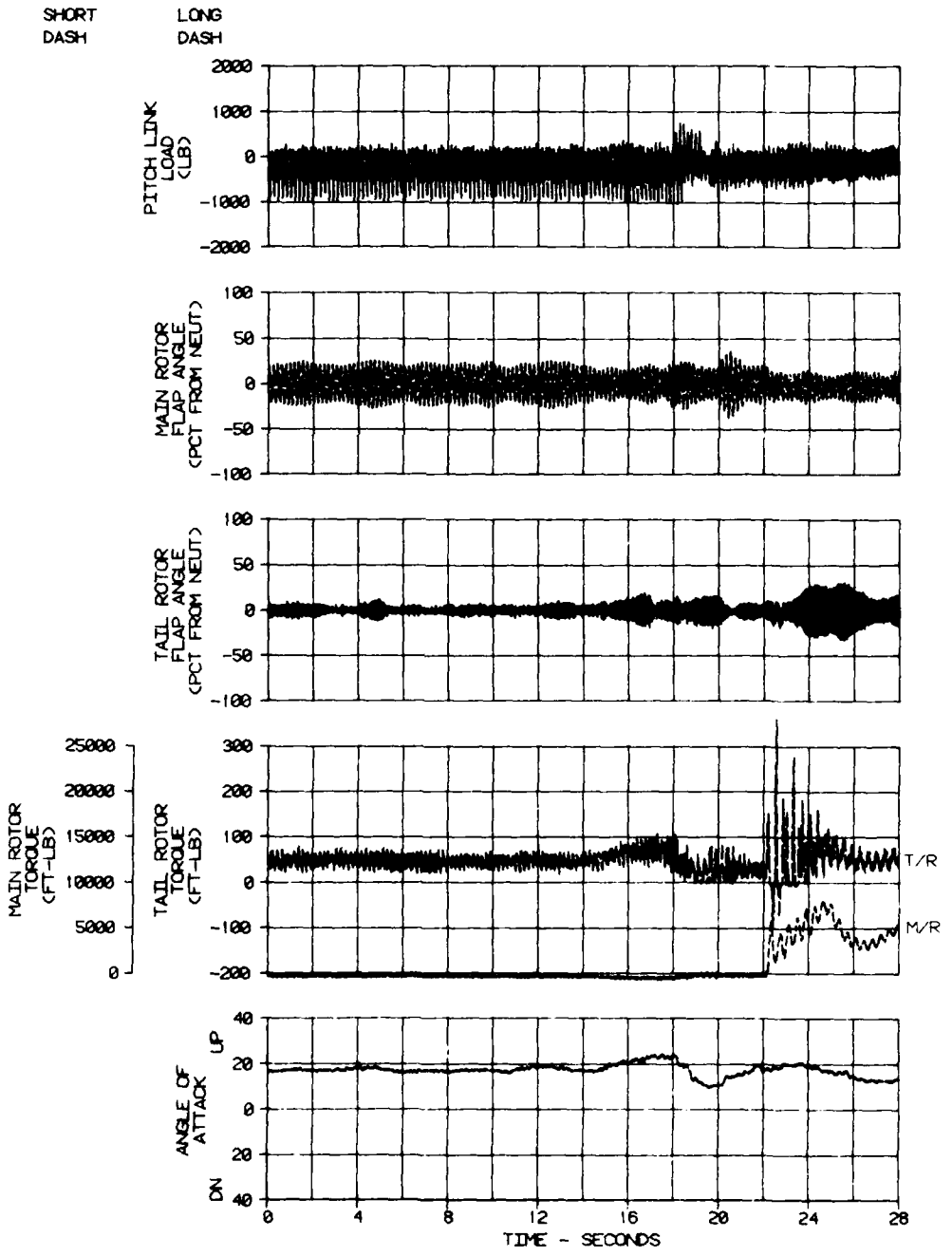


FIGURE E-116A

STRAIGHT APPROACH TO AN AUTOROTATIONAL LANDING

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)
7630	139.9	0.0	3840	18.0	318	98

NOTES: 1. CMRB/HUB SPRNG CONFIGURATION
2. LIMIT LOAD FACTOR = 2.08

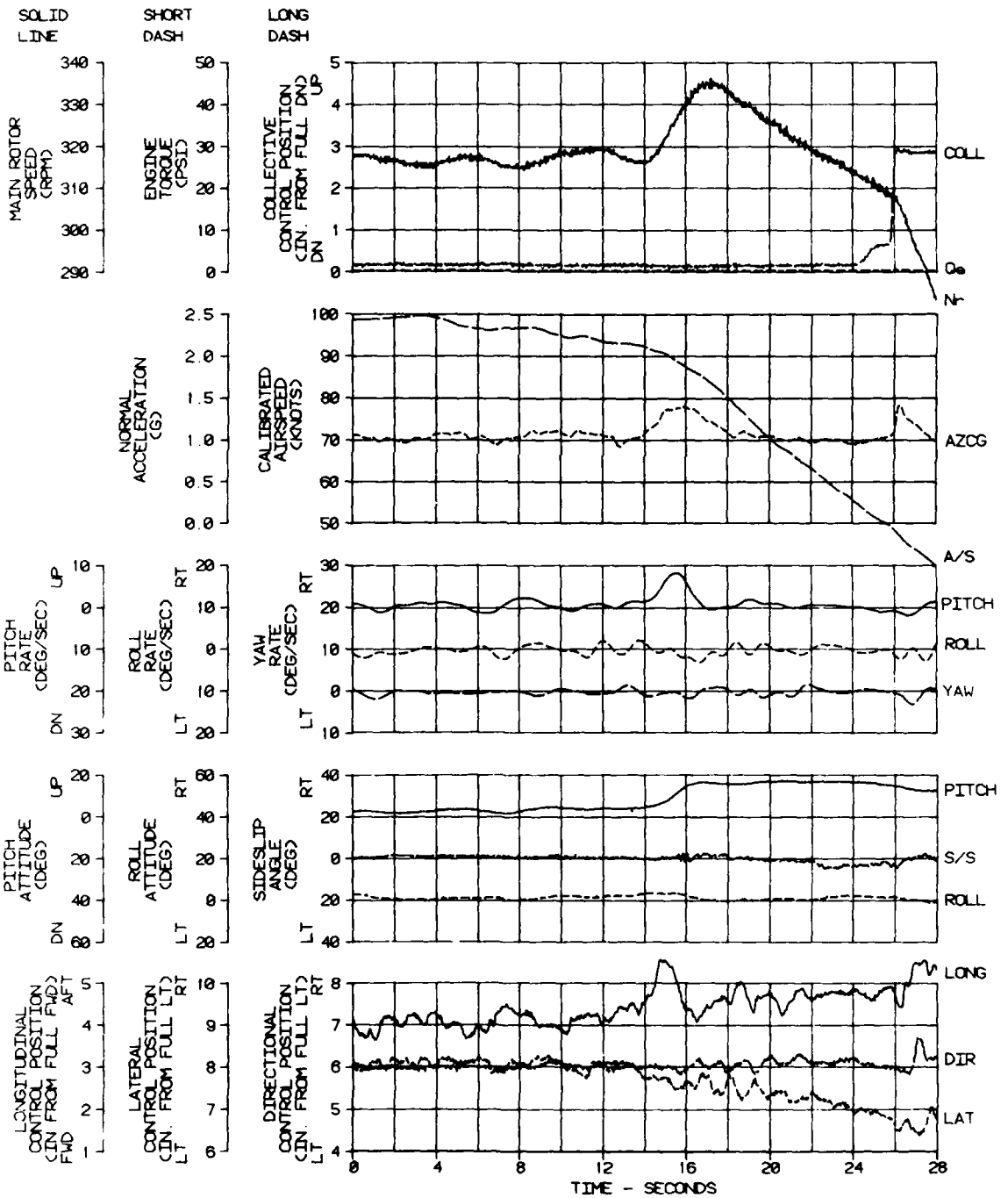


FIGURE E-116B

STRAIGHT APPROACH TO AN AUTOROTATIONAL LANDING

UH-1H USA S/N 68-16358

GROSS WEIGHT	CG LOCATION LONG	CG LOCATION LAT	TRIM DENSITY ALTITUDE	OAT	TRIM ROTOR SPEED	TRIM CALIBRATED AIRSPEED
(LB)	(FS)	(BL)	(FEET)	(DEG C)	(RPM)	(KT)
7630	139.9	0.0	3840	18.0	318	98

NOTES: 1. CMRB/HUB SPRNG CONFIGURATION
2. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING

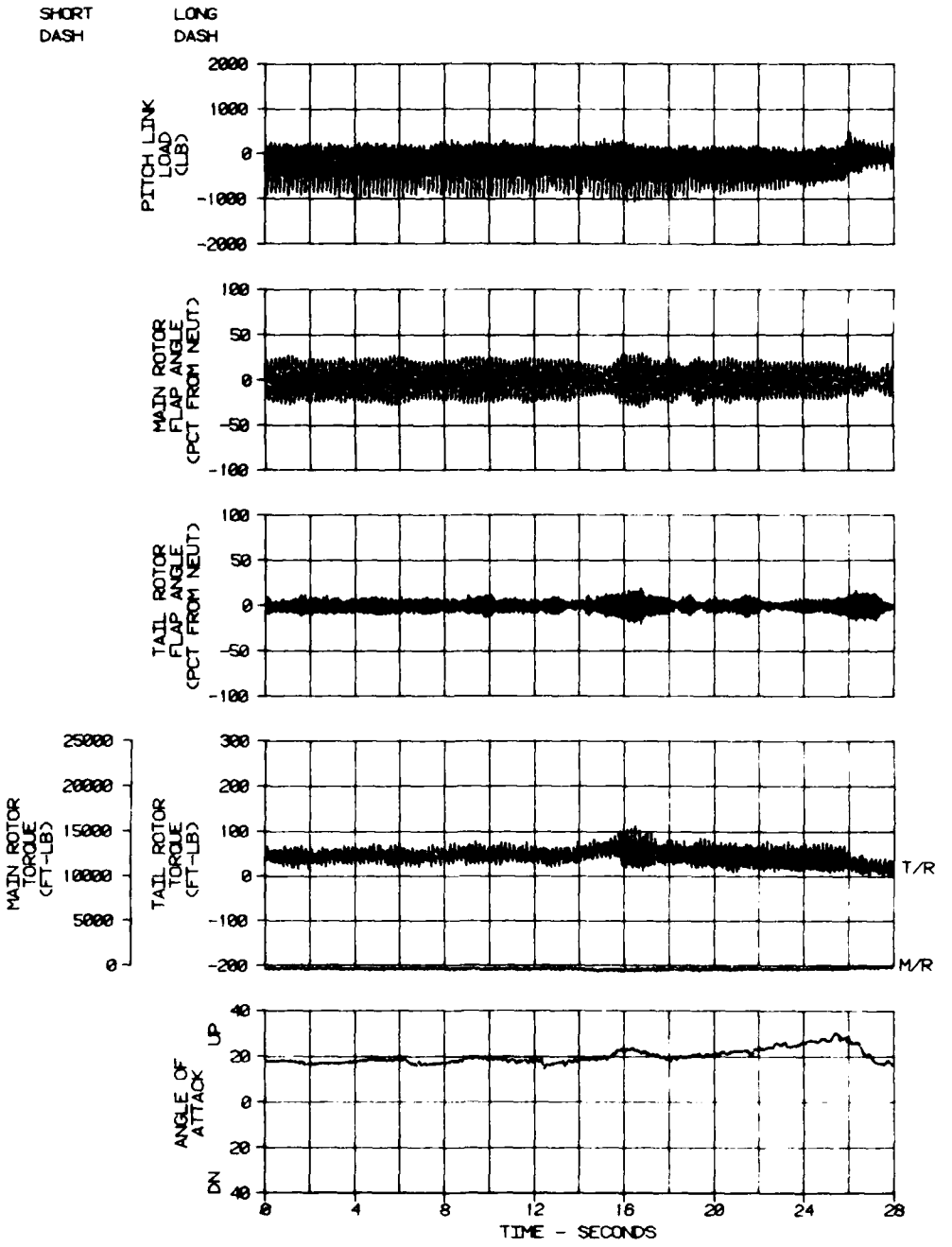


FIGURE E-117A

180 DEG TURN TO AN AUTOROTATIONAL LANDING

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)
7420	139.3	0.0	4300	17.5	314	90

NOTES: 1. PROD CMRB/HUB SPRNG CONFIGURATION
2. LIMIT LOAD FACTOR = 2.11
3. FLOWN IN CROSS WINDS OF 12 KNOTS

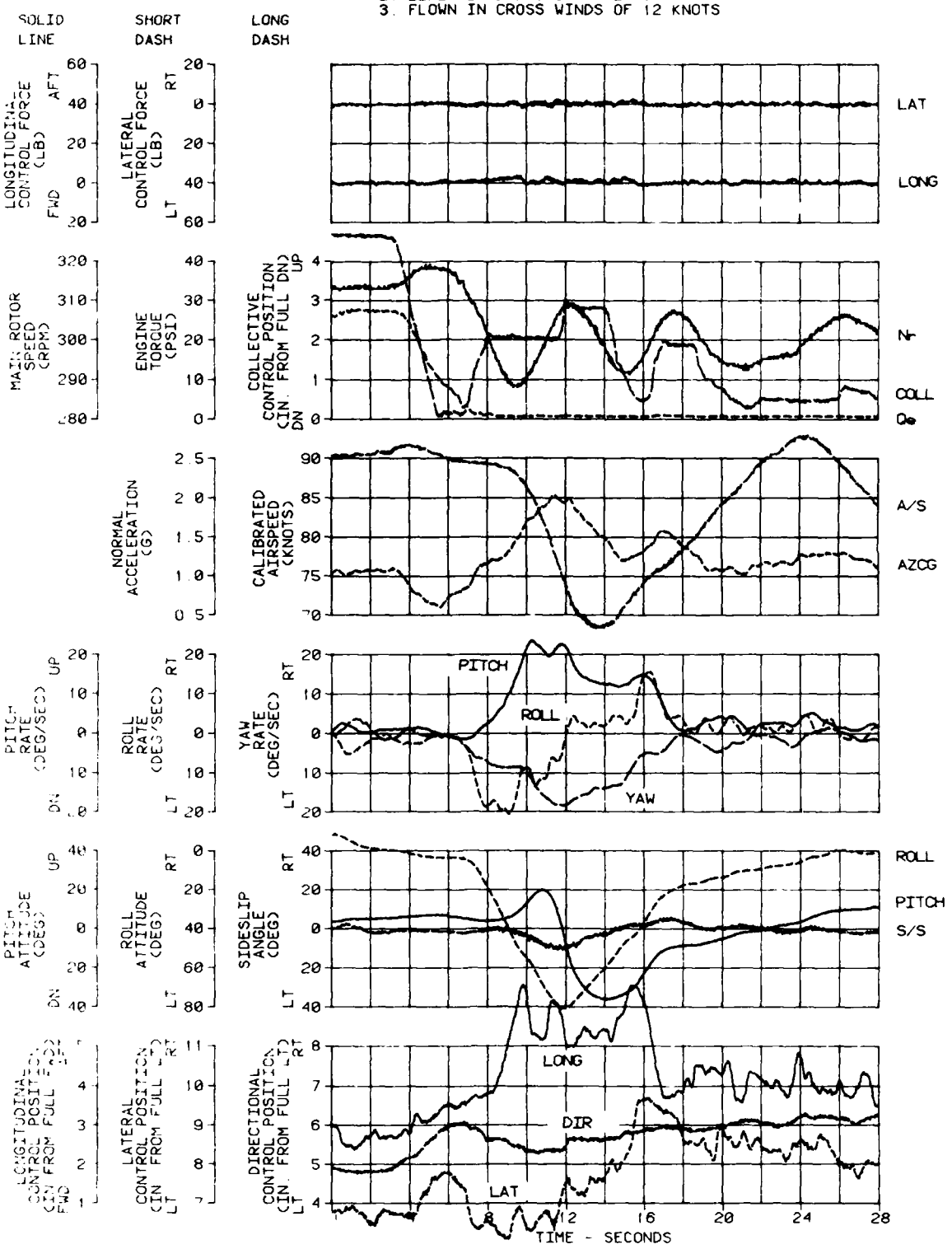


FIGURE E-117B

180 DEG TURN TO AN AUTOROTATIONAL LANDING

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)
7420	139 3	0.0	4300	17 5	314	90

NOTES: 1. PROD CMRB/HUB SPRNG CONFIGURATION
2. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING
3. FLOWN IN CROSS WINDS OF 12 KNOTS

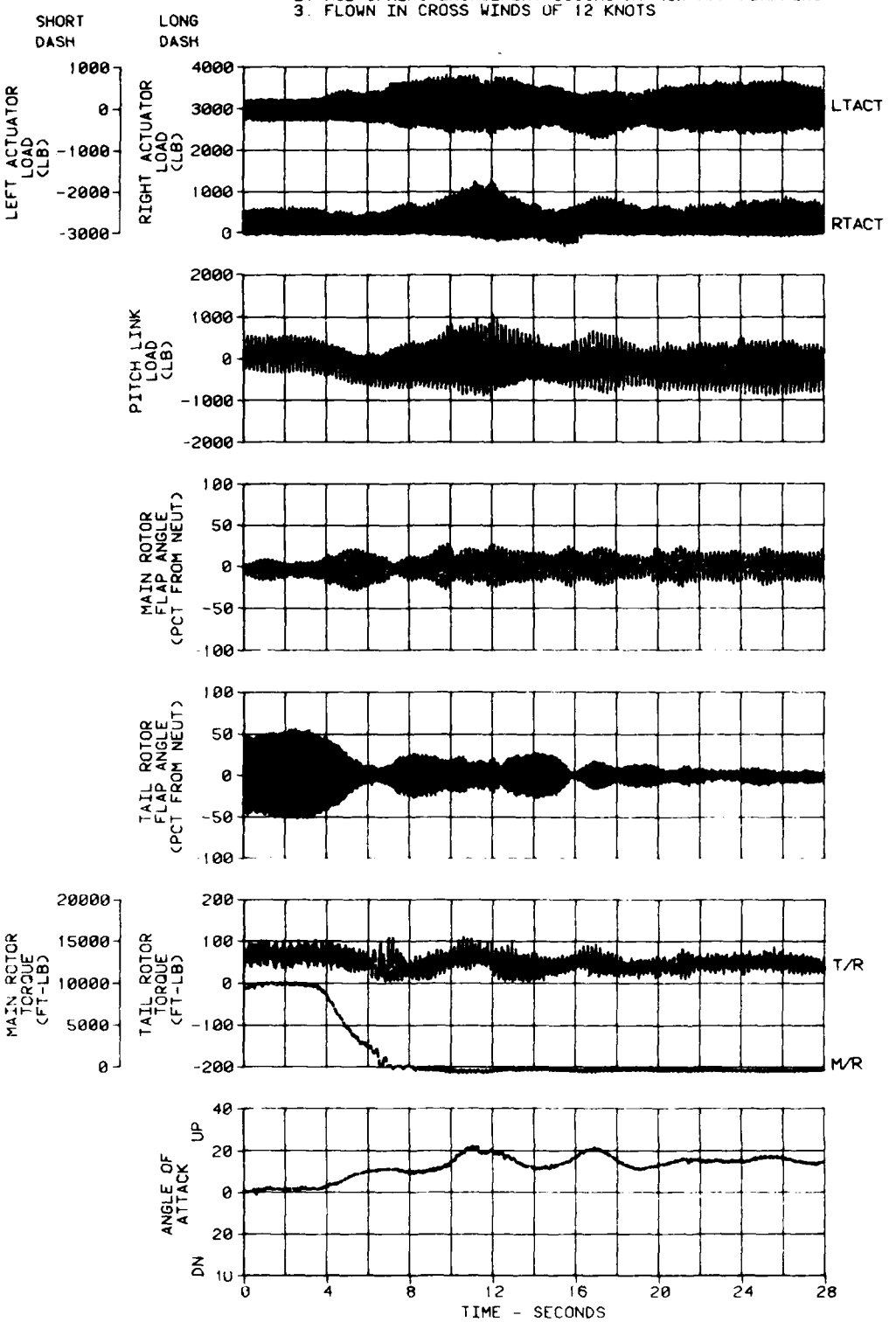


FIGURE E-118A

180 DEG TURN TO AN AUTOROTATIONAL LANDING

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)
7450	139.4	0.0	4350	17.5	314	90

NOTES: 1. PROD CMRB/HUB SPRNG CONFIGURATION
2. LIMIT LOAD FACTOR = 2.10
3. FLOWN IN CROSS WINDS OF 12 KNOTS

SOLID LINE — SHORT DASH — LONG DASH

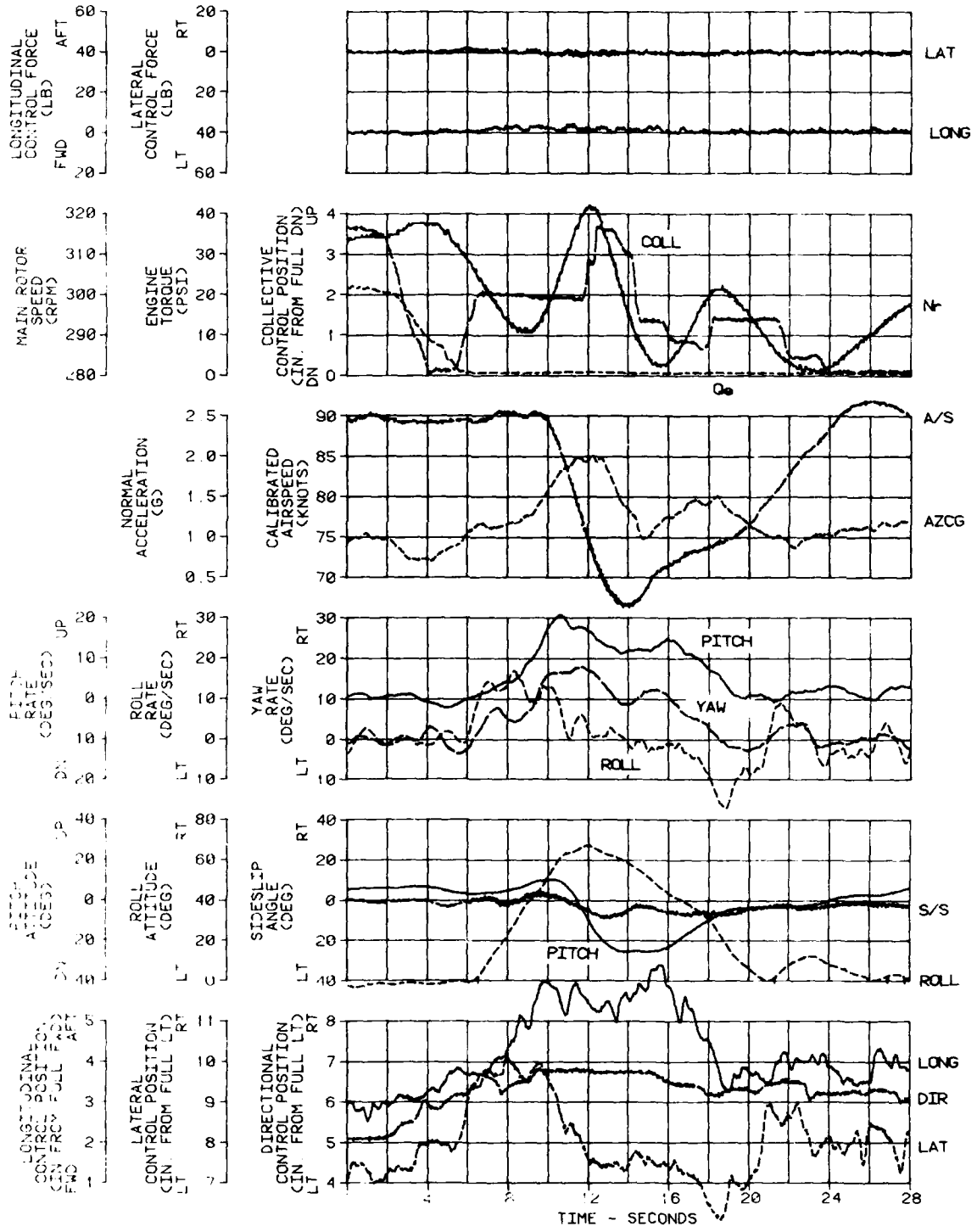


FIGURE E-118B

180 DEG TURN TO AN AUTOROTATIONAL LANDING

UH-1H USA S/N 68-16358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FEET)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)
7450	139.4	0.0	4350	1/ 5	314	(illegible)

NOTES: 1. PROD CMRB/HUB SPRNG CONFIGURATION
2. HUB SPRING ENGAGEMENT OCCURS AT 45% M/R FLAPPING
3. FLOWN IN CROSS WINDS OF 12 KNOTS

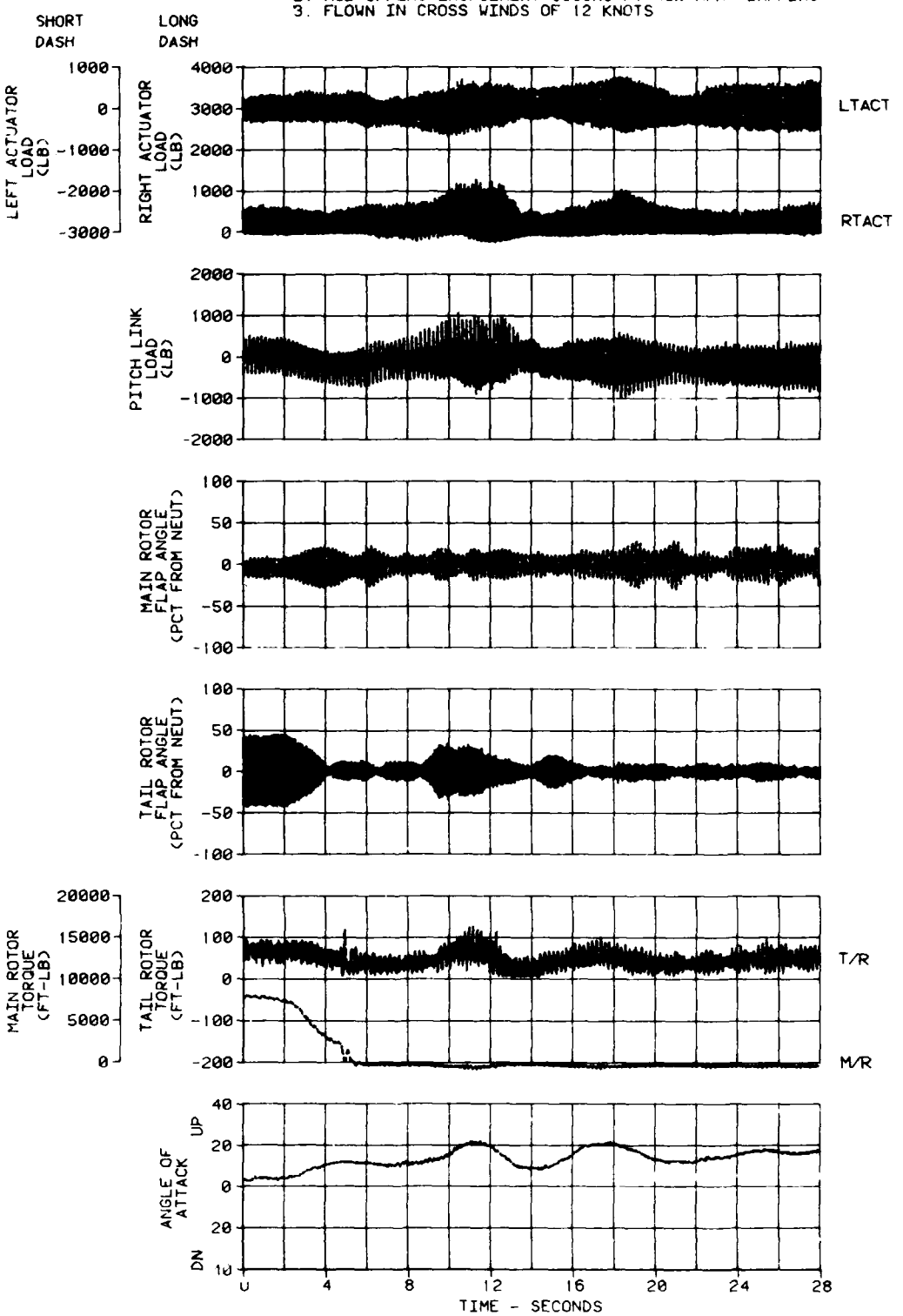


FIGURE E-119

PILOT SEAT VERTICAL 2/REV VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
8770	138.3	0.0	990	1.5	325	HOVER	CMRB/HUB SPRNG
8640	137.8	0.0	3620	4.0	313	LEVEL	CMRB/HUB SPRNG

NOTES:
1. ⊡ DENOTES 2/REV
2. ⊙ DENOTES PILOT VIBRATION RATING
3. CROSSED SYMBOL DENOTES IN-GROUND EFFECT HOVER

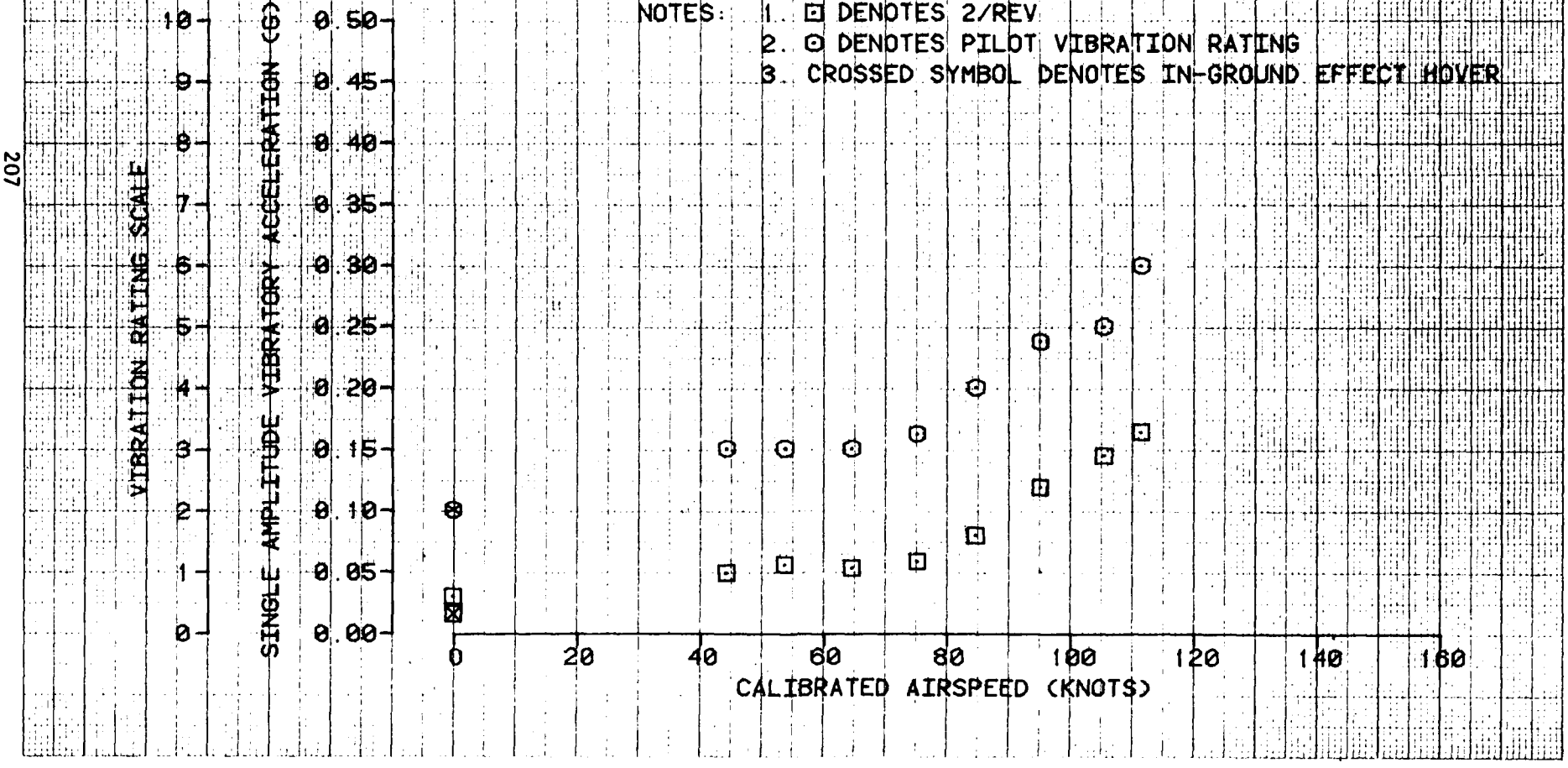


FIGURE E-120

COPILOT SEAT VERTICAL 2/REV VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
8770	138.3	0.0	990	1.5	325	HOVER	CMRB/HUB SPRNG
8640	137.8	0.0	3620	4.0	313	LEVEL	CMRB/HUB SPRNG

NOTES:
1. ⊡ DENOTES 2/REV
2. ⊙ DENOTES COPILOT VIBRATION RATING
3. CROSSED SYMBOL DENOTES IN-GROUND EFFECT HOVER

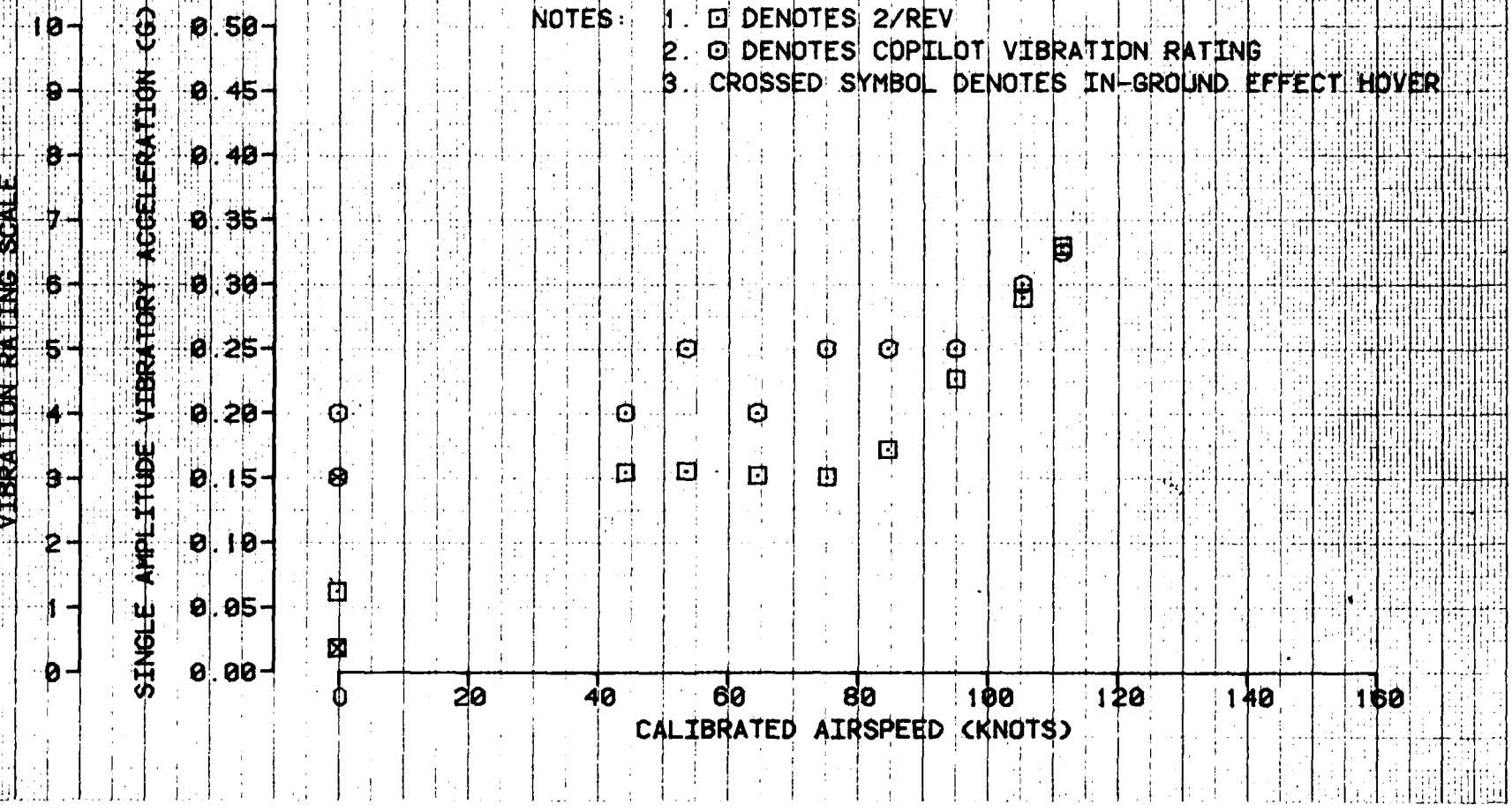


FIGURE E-121

PILOT SEAT VERTICAL 2/REV VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIB AIRSPEED	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
8690	137.6	0.0	6150	1.0	314	96	WIND UP TURN	CMRB/HUB SPRNG

NOTES 1. ⊡ DENOTES 2/REV
2. ⊙ DENOTES PILOT VIBRATION RATING

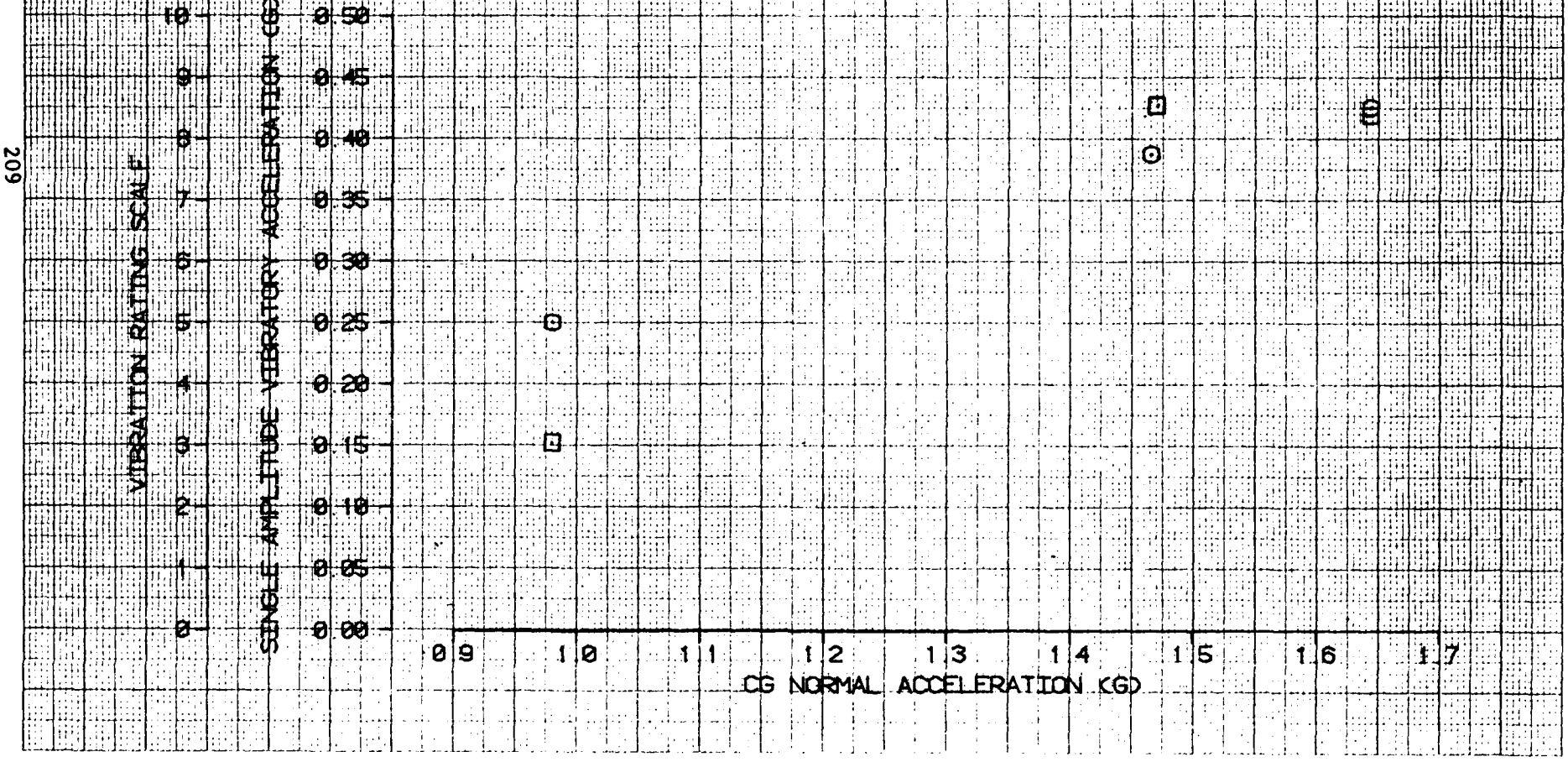


FIGURE E-122

COPILOT SEAT VERTICAL 2/REV VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIB AIRSPEED	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
8690	137.6	0.0	6150	1.0	314	96	WIND UP TURN	CMRB/HUB SPRNG

NOTES: 1. ⊡ DENOTES 2/REV
2. ⊙ DENOTES COPILOT VIBRATION RATING

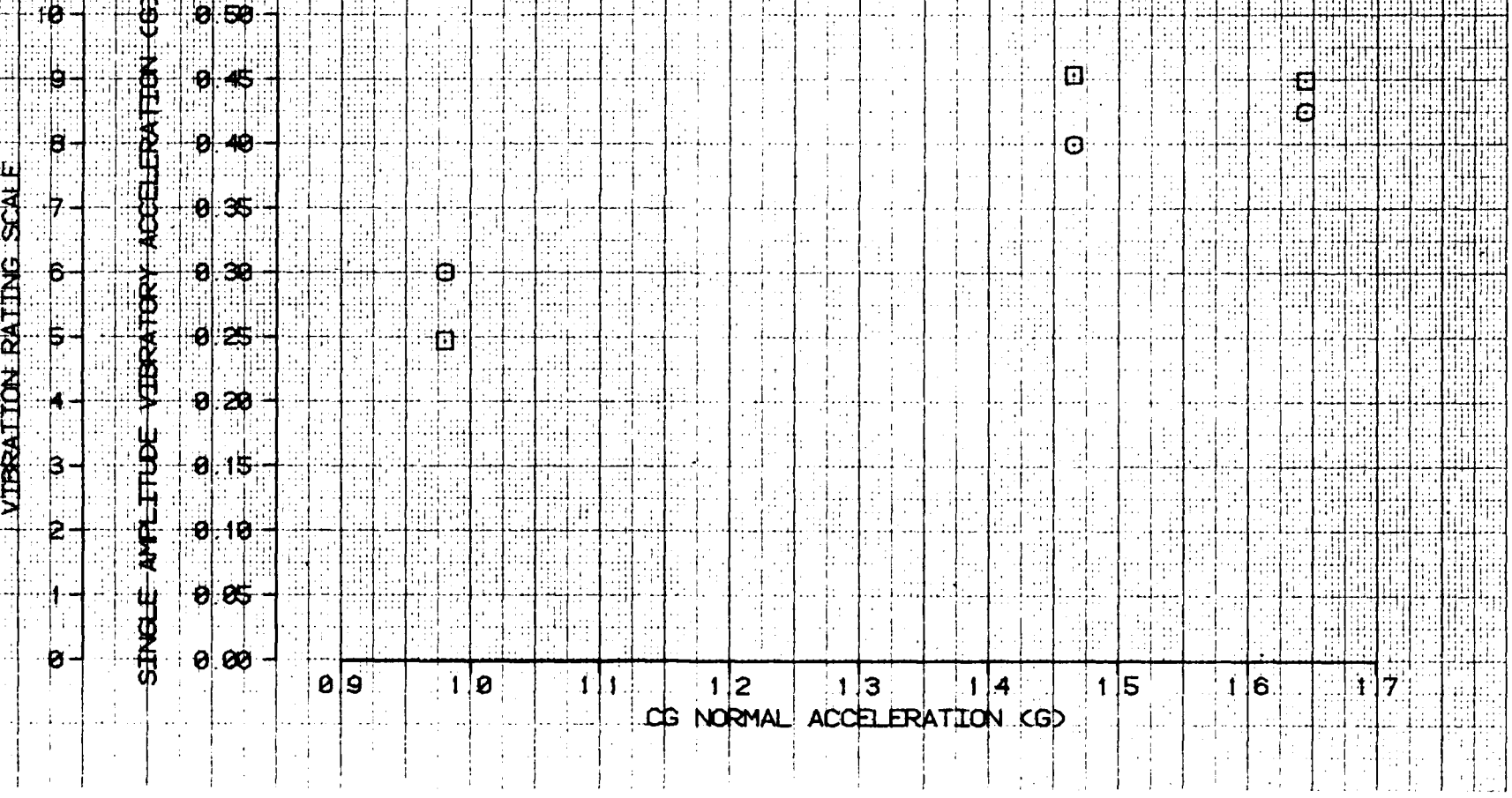


FIGURE E-123

PILOT SEAT VERTICAL 2/REV VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
9060	138.7	0.0	1290	5.5	324	HOVER	STD/HUB SPRNG
8920	138.2	0.0	3690	12.0	325	LEVEL	STD/HUB SPRNG

NOTES:
1. ⊡ DENOTES 2/REV
2. ⊙ DENOTES PILOT VIBRATION RATING
3. CROSSED SYMBOL DENOTES IN-GROUND EFFECT HOVER

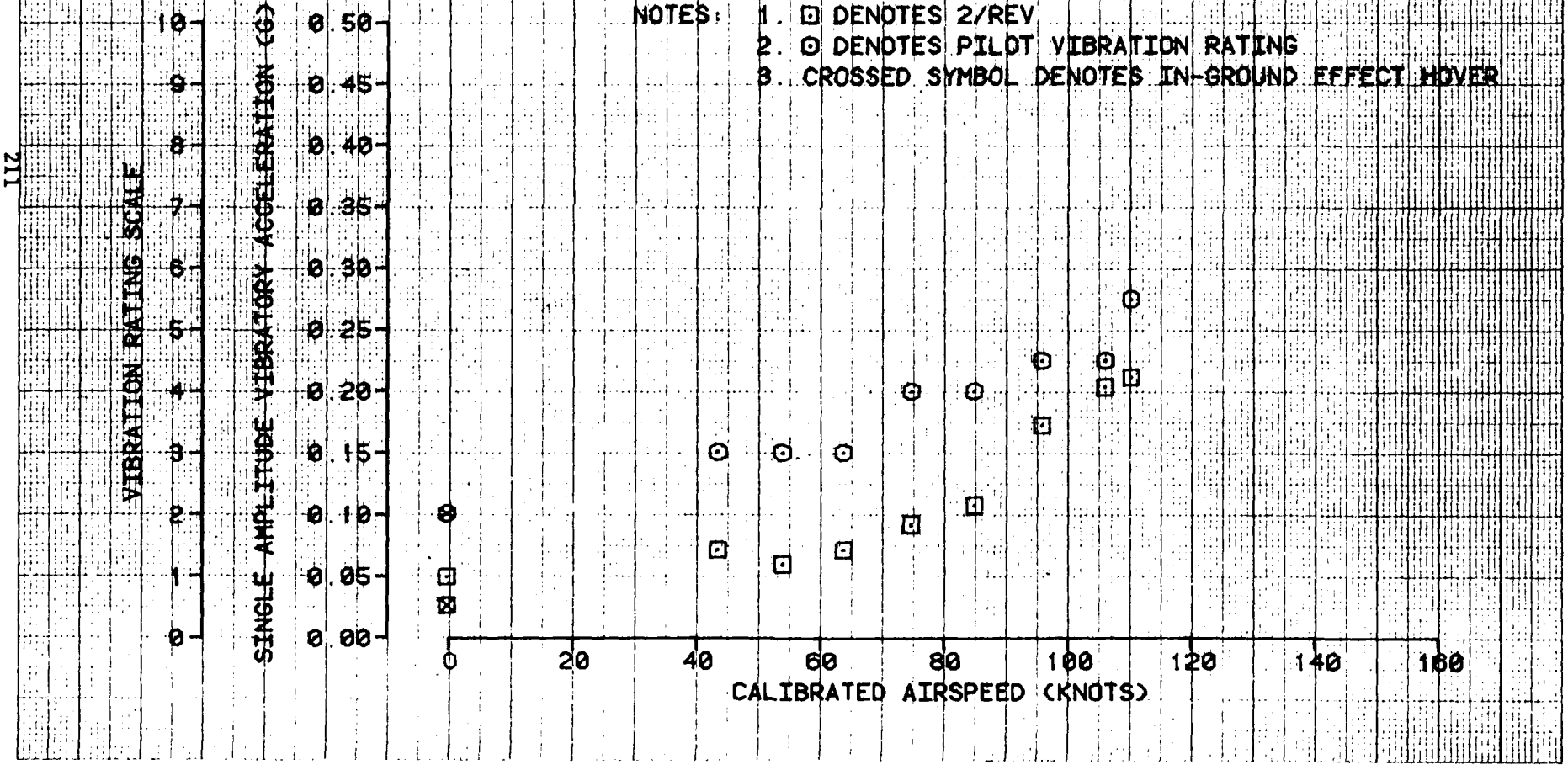


FIGURE E-124

COPILOT SEAT VERTICAL 2/REV VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
9060	138.7	0.0	1290	5.5	324	HOVER	STD/HUB SPRNG
8920	138.2	0.0	3690	12.0	325	LEVEL	STD/HUB SPRNG

NOTES:
1. ⊡ DENOTES 2/REV
2. ⊙ DENOTES COPILOT VIBRATION RATING
3. CROSSED SYMBOL DENOTES IN-GROUND EFFECT HOVER

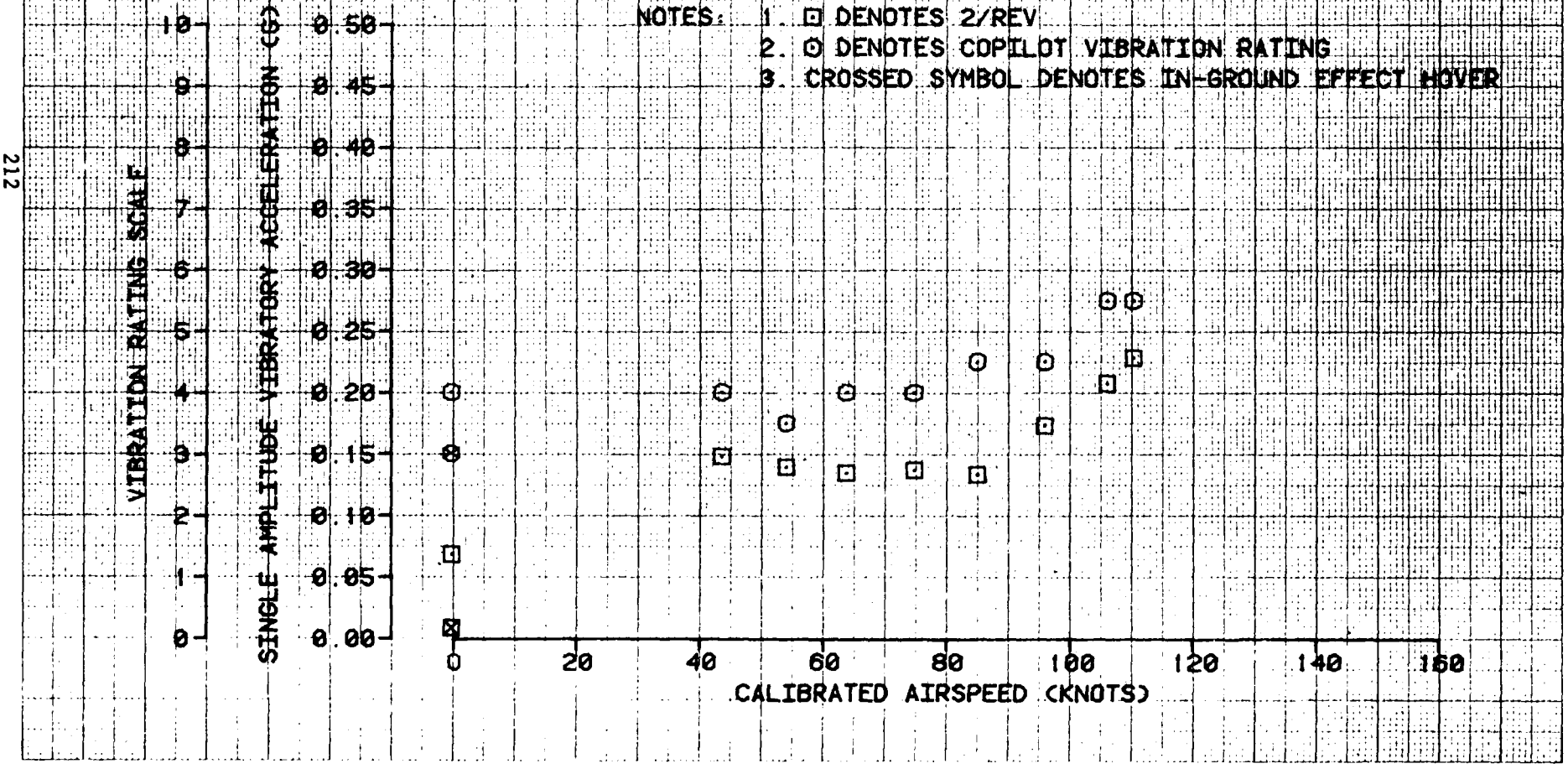


FIGURE E-125

PILOT SEAT VERTICAL 2/REV VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIB AIRSPEED	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
8630	137.2	0.0	5750	9.0	324	96	WIND UP TURN	STD/HUB SPRNG

NOTES: 1. □ DENOTES 2/REV

2. ○ DENOTES PILOT VIBRATION RATING

FIGURE E-126

COPILOT SEAT VERTICAL 2/REV VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIB AIRSPEED	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
8630	137.2	0.0	5750	9.0	324	96	WIND UP TURN	SID/HUB SPRING

NOTES: 1. ⊡ DENOTES 2/REV
2. ⊙ DENOTES COPILOT VIBRATION RATING

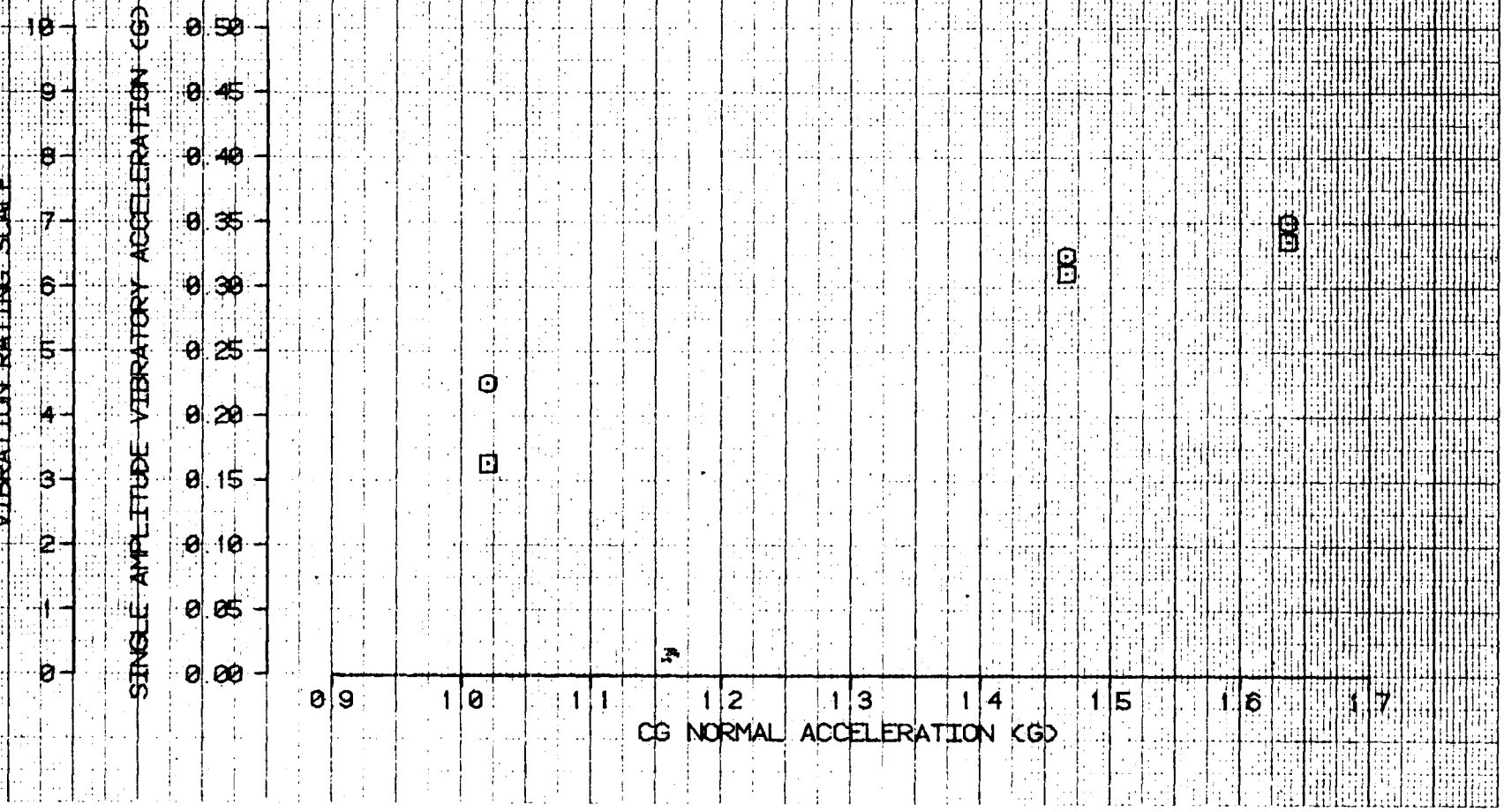


FIGURE E-127

PILOT SEAT VERTICAL VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
8690	137.6	0.0	8230	-0.5	313	LEVEL	CMRB/HUB SPRNG
8460	139.9	0.0	7990	23.5	314	LEVEL	PROD CMRB/HUB SPRNG

NOTES: 1. ⊡ = 1/REV, ⊙ = 2/REV
2. SHADED SYMBOLS DENOTE PROD CMRB/HUB SPRNG
3. LINE REPRESENTS MILITARY SPECIFICATION, MIL-H-8501A, VIBRATION LIMIT

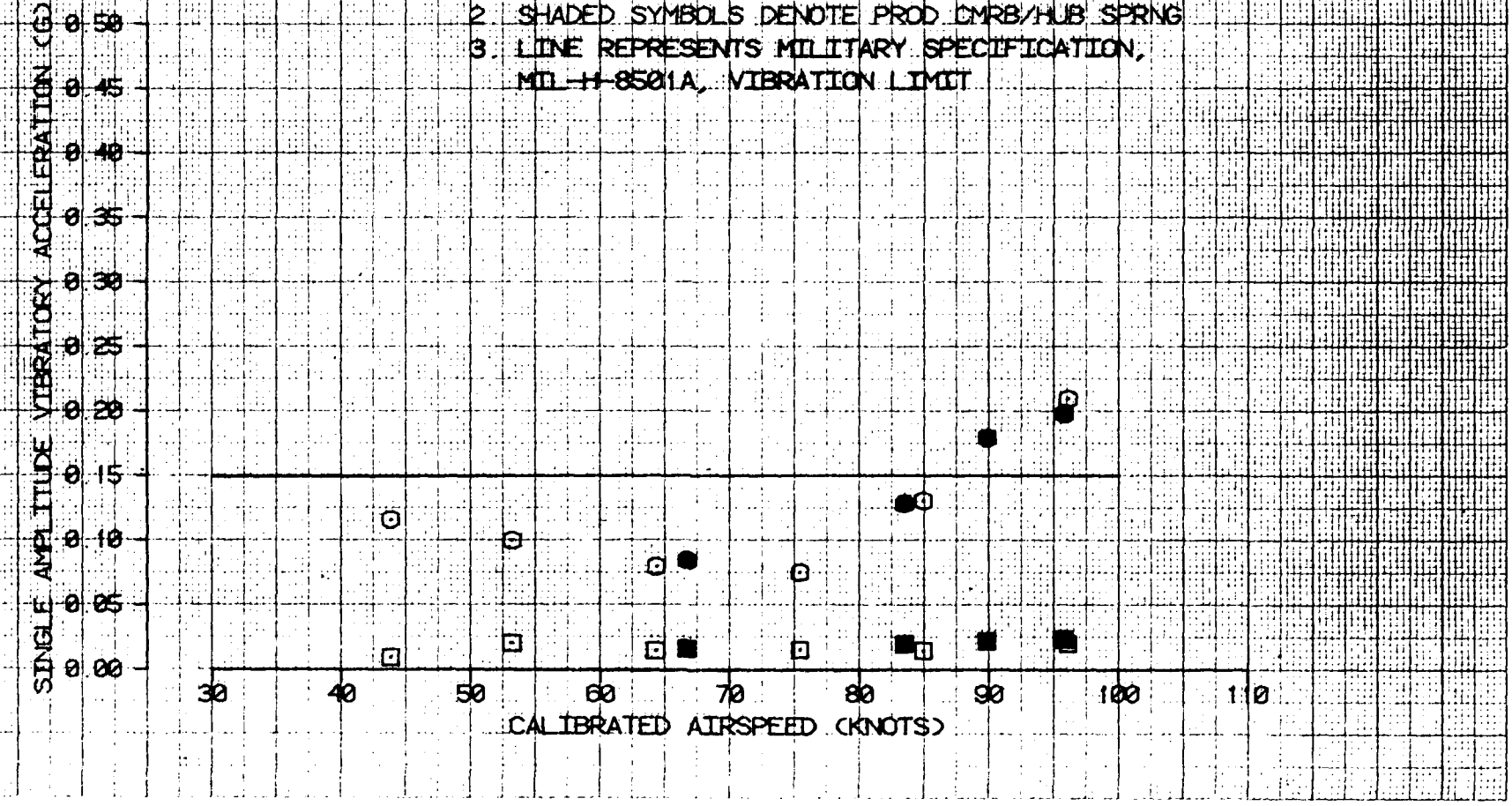


FIGURE B-128

PILOT SEAT LATERAL VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
8690	137.6	0.0	8230	-0.5	313	LEVEL	CMRB/HUB SPRING
8460	139.9	0.0	7990	23.5	314	LEVEL	PROD CMRB/HUB SPRING

NOTES: 1. ⊡ = 1/REV; ⊙ = 2/REV
2. SHADED SYMBOLS DENOTE PROD CMRB/HUB SPRING

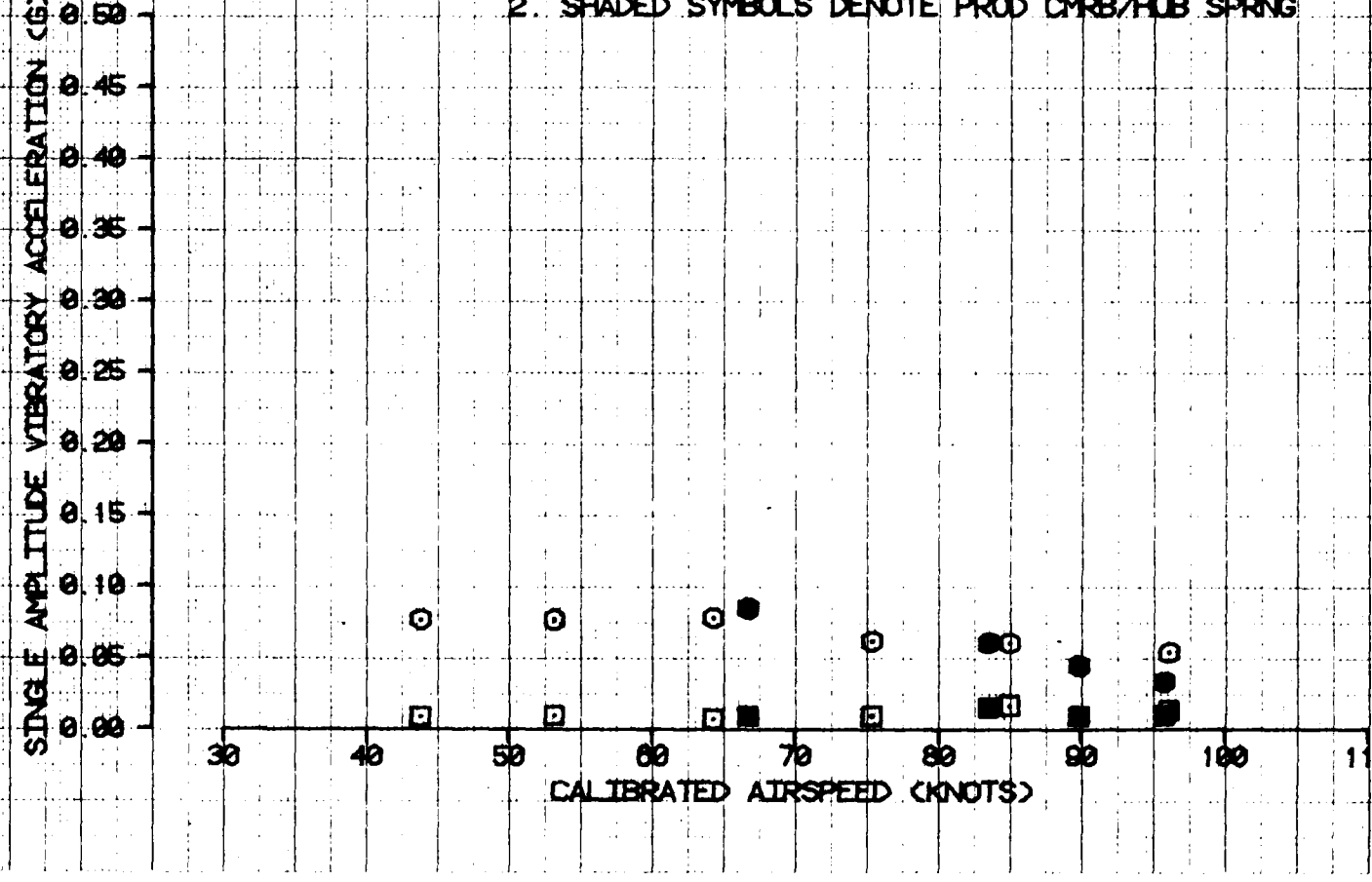


FIGURE E-129

COPILOT SEAT VERTICAL VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
8690	137.6	0.0	8230	-0.5	313	LEVEL	CMRB/HUB SPRNG
8480	139.9	0.0	7990	23.5	314	LEVEL	PROD CMRB/HUB SPRNG

NOTES: 1. ⊡ = 1/REV; ⊙ = 2/REV.
2. SHADED SYMBOLS DENOTE PROD CMRB/HUB SPRNG
3. LINE REPRESENTS MILITARY SPECIFICATION, MIL-H-8501A, VIBRATION LIMIT

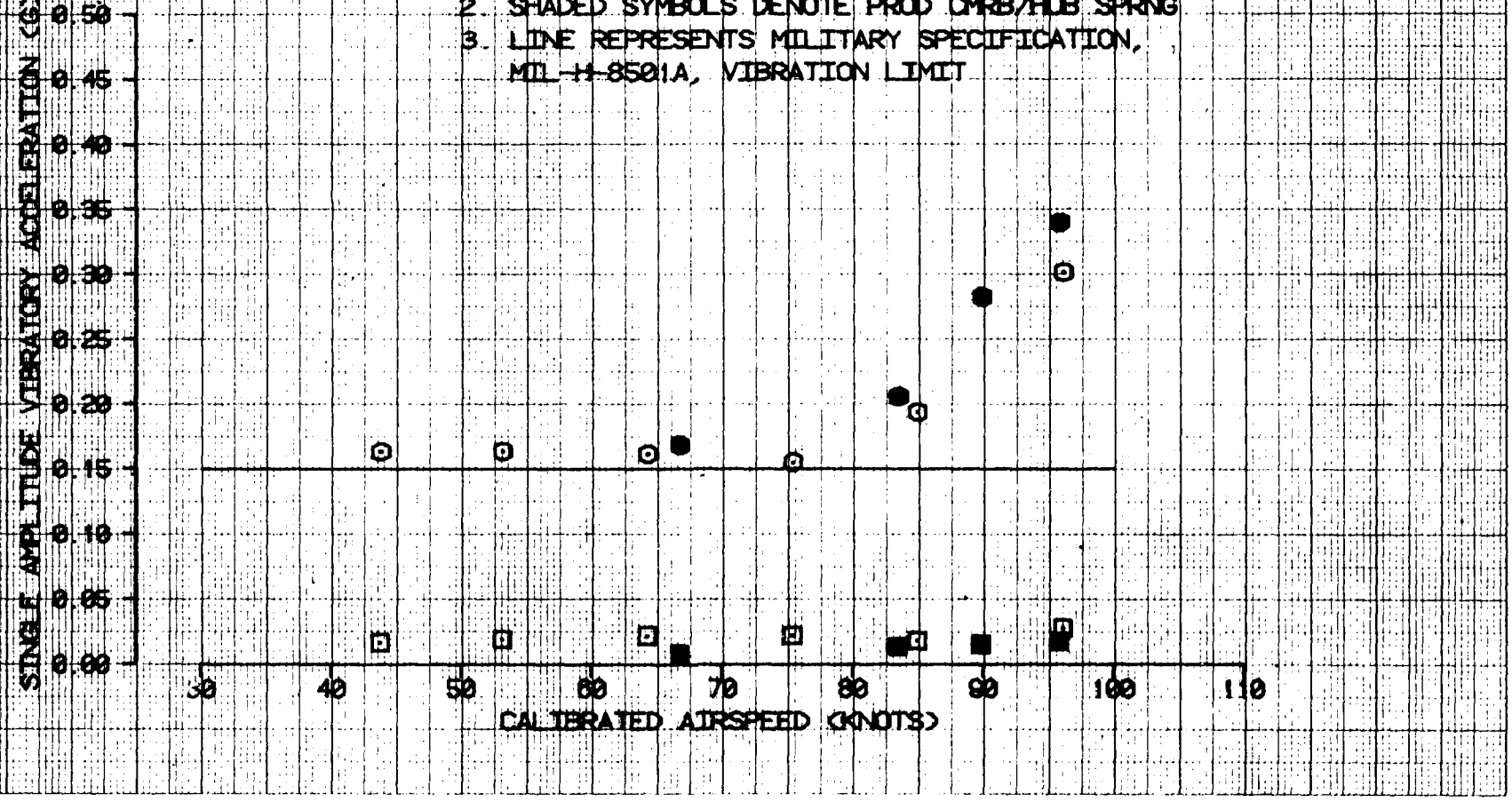


FIGURE E-130

COPILOT SEAT LATERAL VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
8690	137.8	0.0	8230	-0.5	313	LEVEL	CMRB/HUB SPRNG
8460	139.9	0.0	7990	23.5	314	LEVEL	PROD CMRB/HUB SPRNG

NOTES: 1. ⊡ = 1/REV, ⊙ = 2/REV.
2. SHADED SYMBOLS DENOTE PROD CMRB/HUB SPRNG

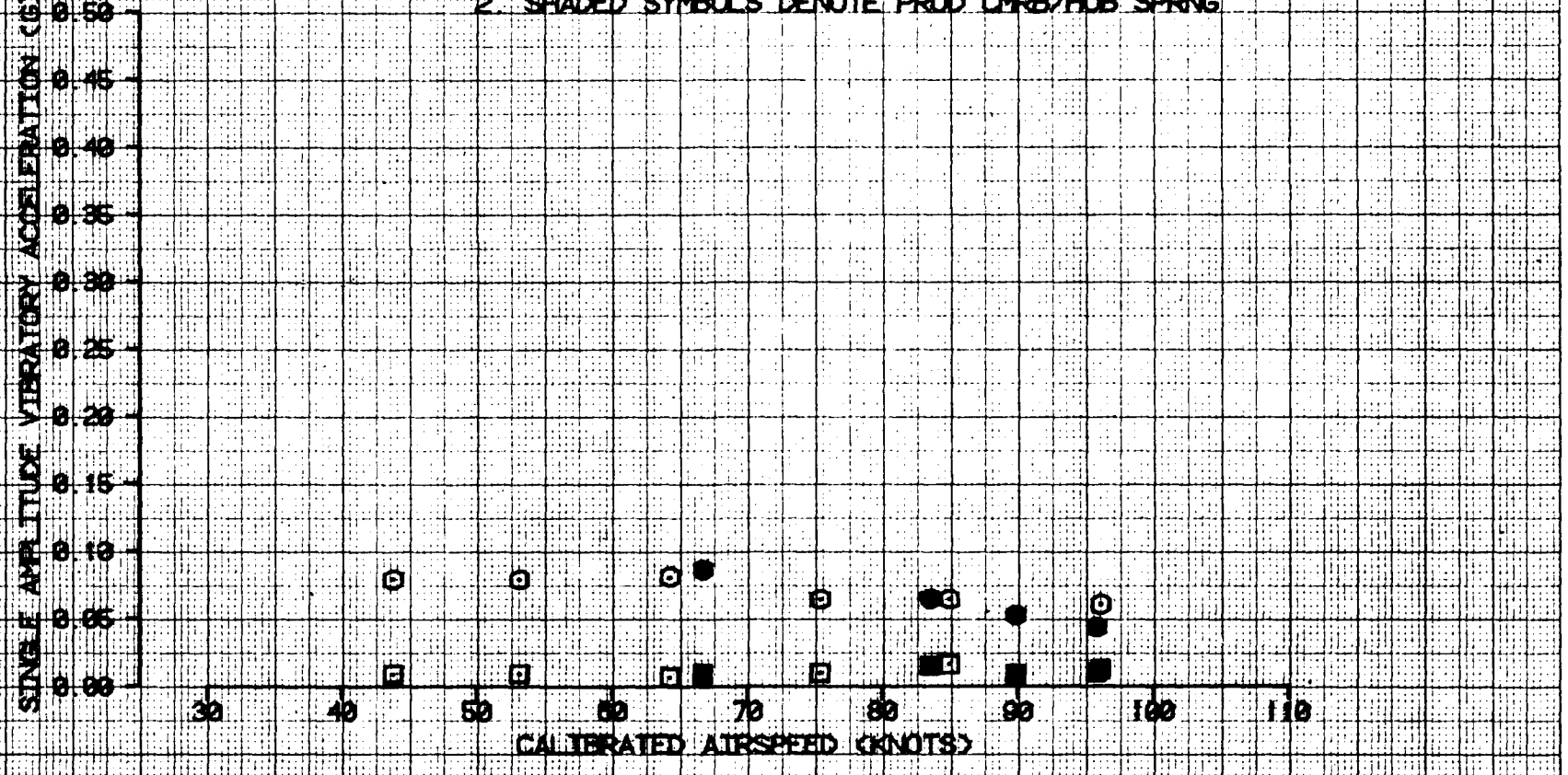


FIGURE E-131

CENTER OF GRAVITY VERTICAL VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
8690	137.6	0.0	8230	-0.5	313	LEVEL	CMRB/HUB SPRNG
8460	139.9	0.0	7990	23.5	314	LEVEL	PROD CMRB/HUB SPRNG

NOTES: 1. □ = 1/REV, ○ = 2/REV
2. SHADED SYMBOLS DENOTE PROD CMRB/HUB SPRNG

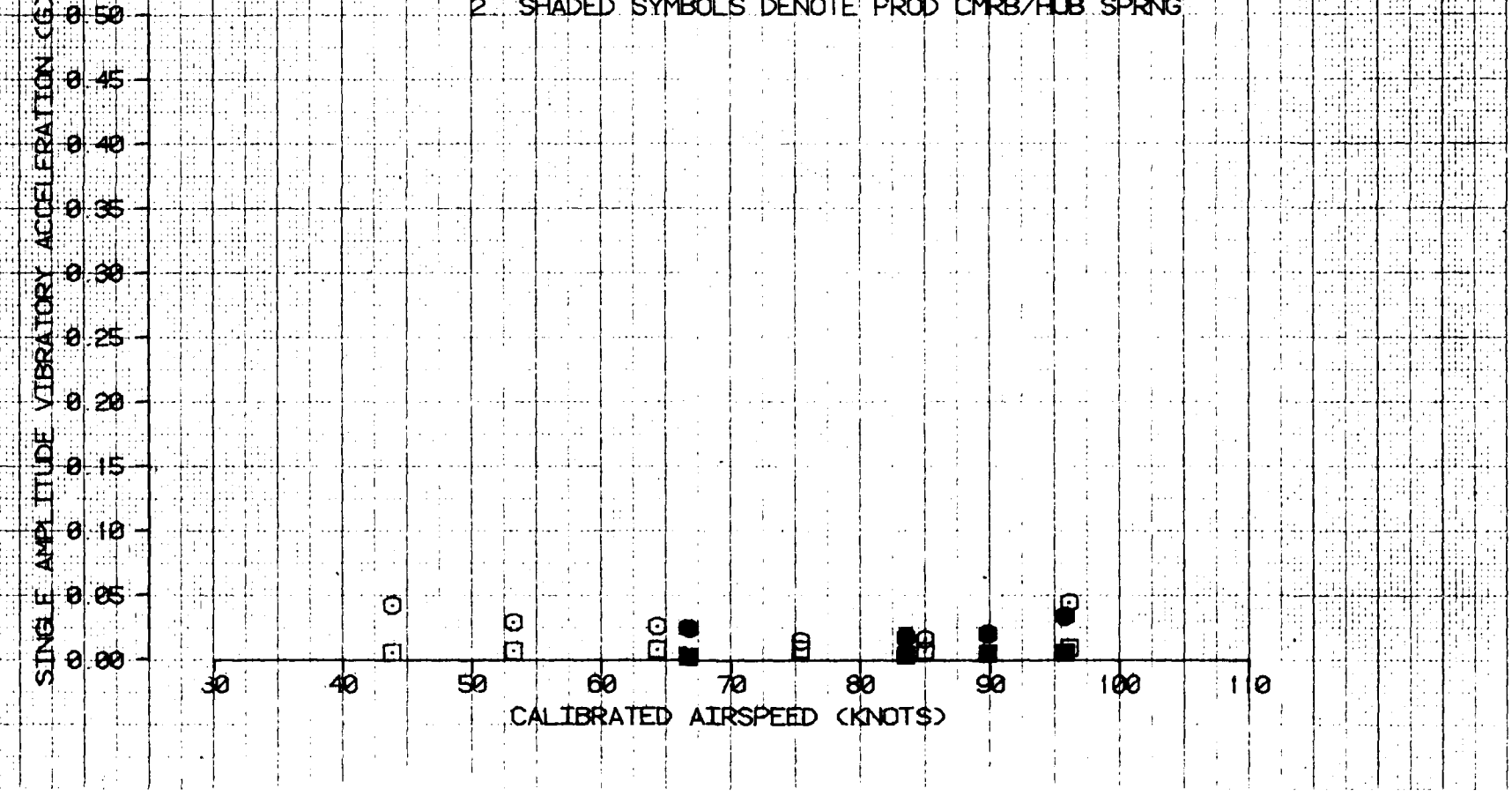


FIGURE E-132

PILOT SEAT VERTICAL VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
8840	138.1	0.0	6140	1.0	313	LEVEL	CMRB/HUB SPRNG

NOTE: □ = 1/REV; ⊙ = 2/REV; △ = 4/REV; ▽ = 6/REV; ◇ = 8/REV

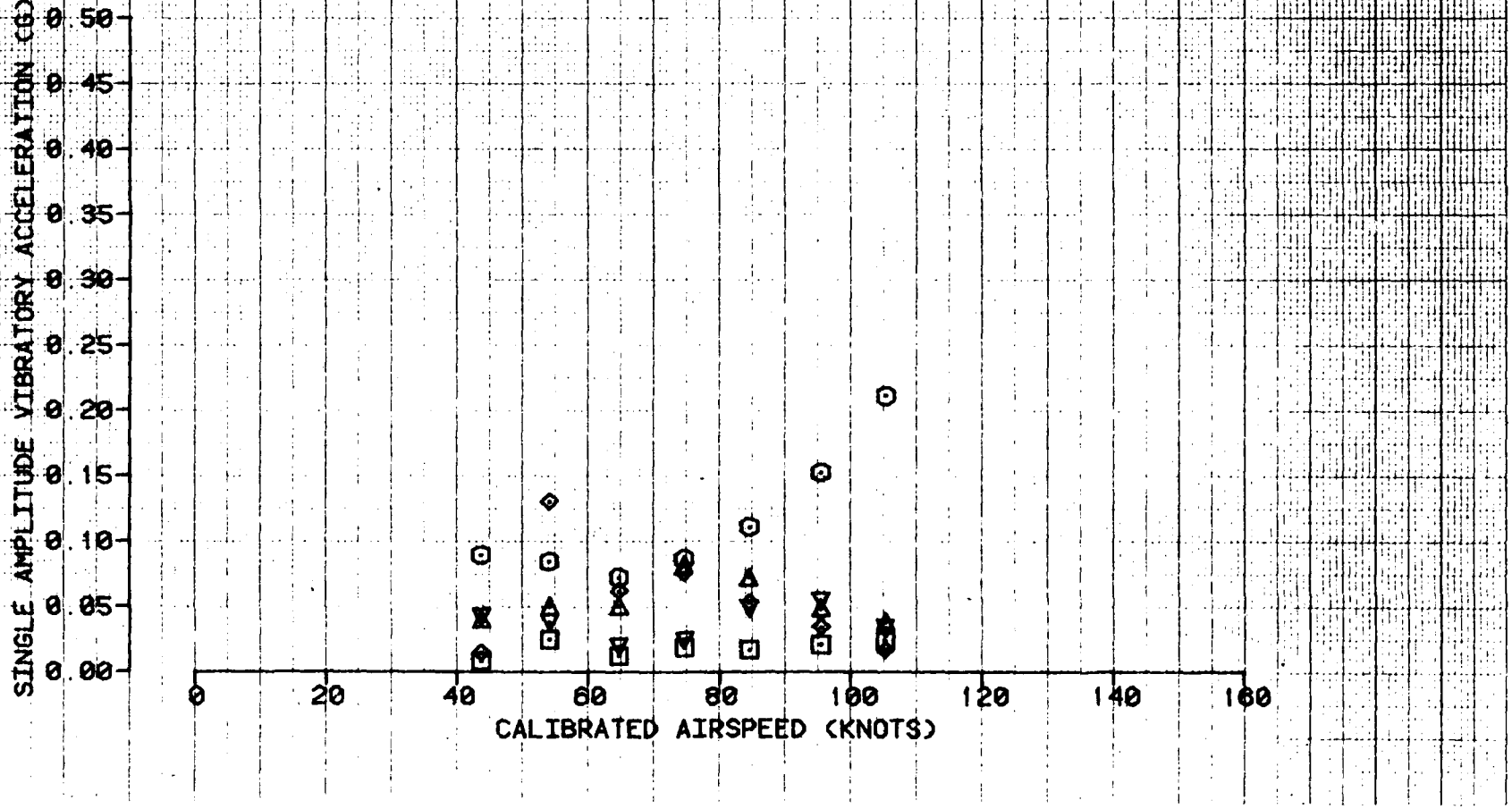


FIGURE E-133

PILOT SEAT LATERAL VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
8840	138.1	0.0	6140	1.0	313	LEVEL	CMRB/HUB SPRNG

NOTE: □ = 1/REV, ○ = 2/REV, △ = 4/REV, ▽ = 6/REV, ◇ = 8/REV

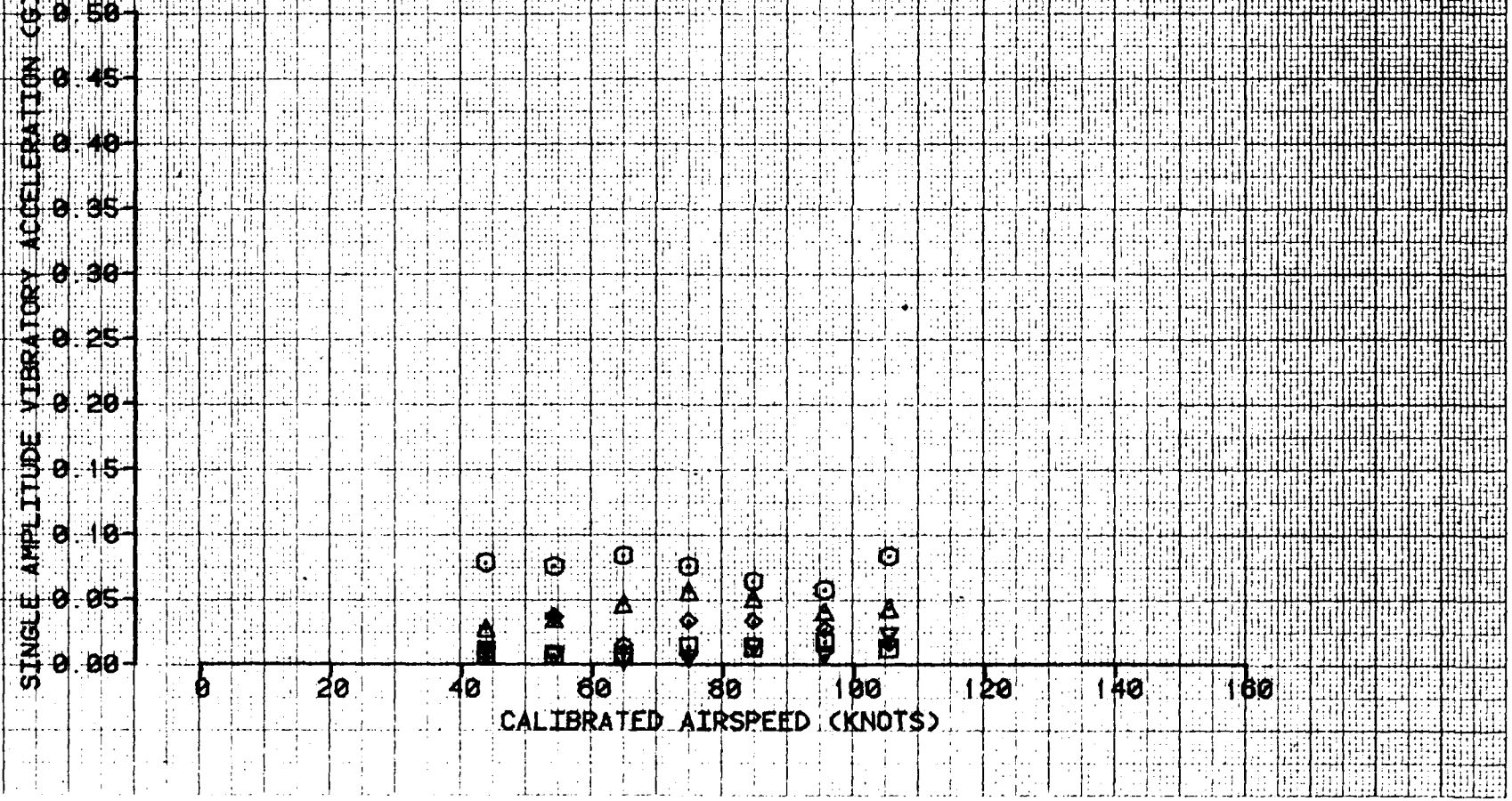


FIGURE E-134

PILOT SEAT LONGITUDINAL VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
8840	138.1	0.0	6140	1.0	313	LEVEL	CMRB/HUB SPRNG

NOTE: ⊡ = 1/REV; ⊙ = 2/REV; △ = 4/REV; ▽ = 6/REV; ◇ = 8/REV

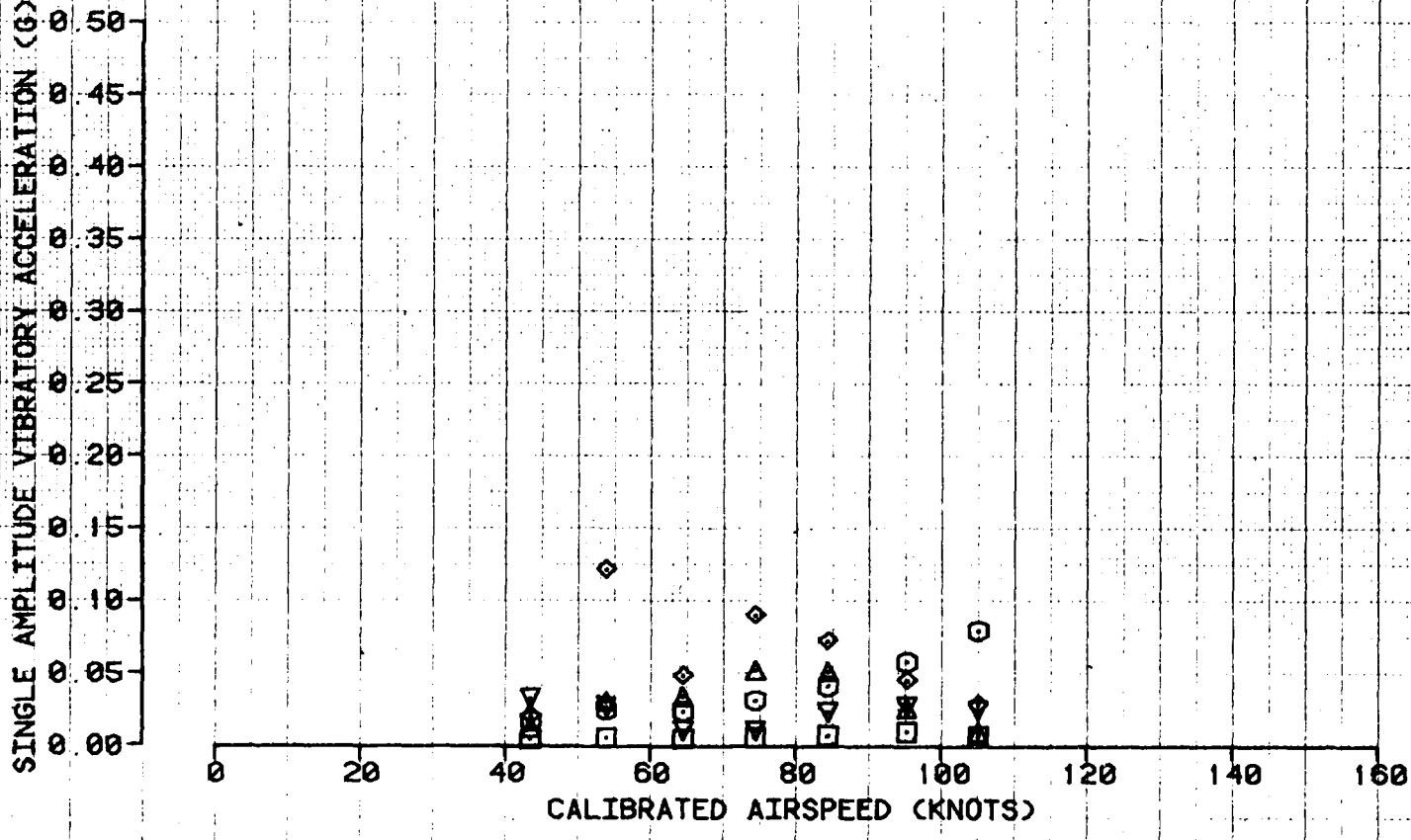


FIGURE E-135

COPILOT SEAT VERTICAL VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
8840	138.1	0.0	6140	1.0	313	LEVEL	CMRB/HUB SPRNG

NOTE: □ = 1/REV; ○ = 2/REV; △ = 4/REV; ▽ = 6/REV; ◇ = 8/REV

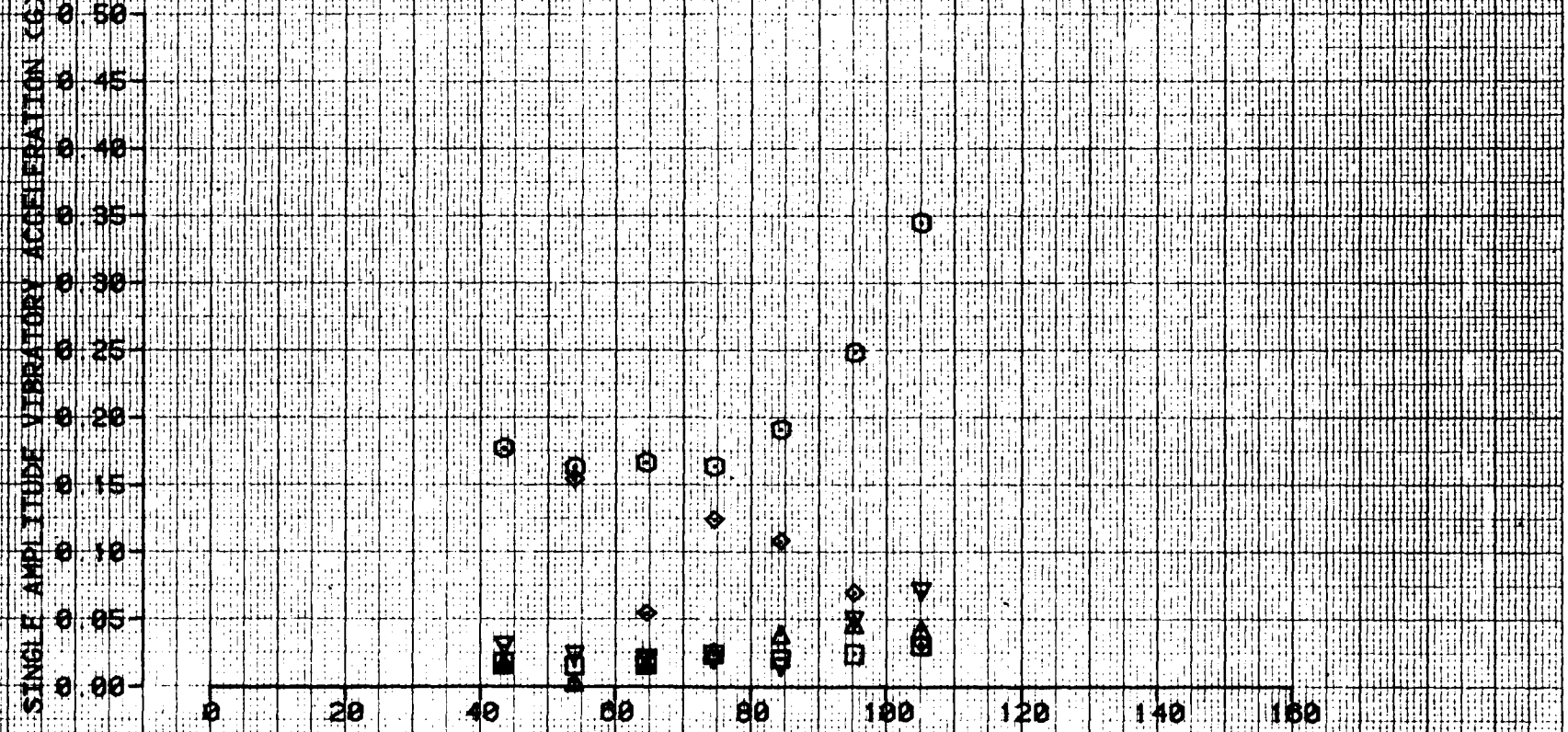


FIGURE B-136

COPILOT SEAT LATERAL VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
8840	138.1	0.0	6140	1.0	313	LEVEL	CMRB/HUB SPRNG

NOTE: ⊡ = 1/REV; ⊙ = 2/REV; △ = 4/REV; ▽ = 6/REV; ◇ = 8/REV

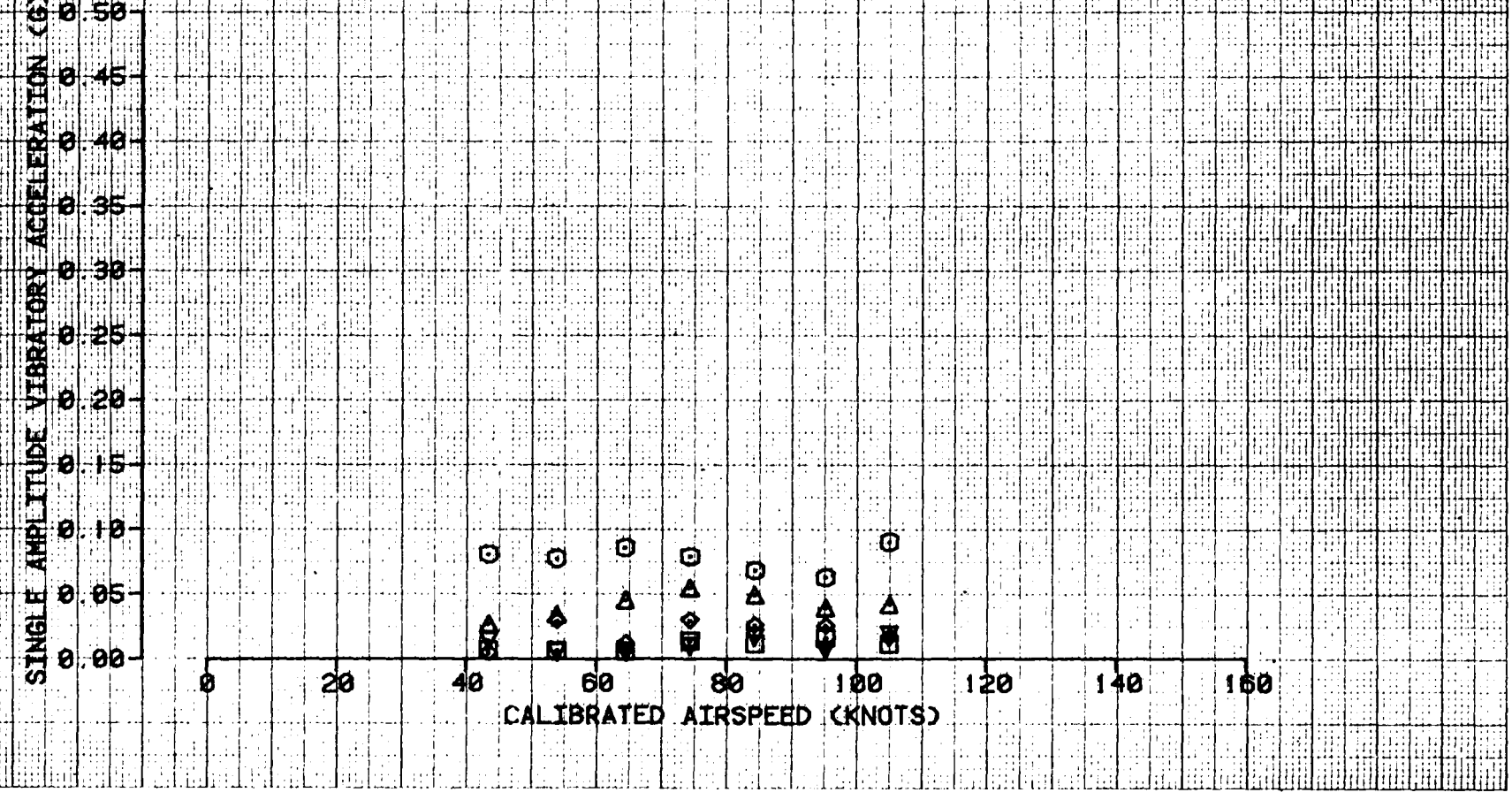


FIGURE E-137

COPILOT SEAT LONGITUDINAL VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
8840	138.1	0.0	6140	1.0	313	LEVEL	CMRB/HUB SPRNG

NOTE: ⊡ = 1/REV; ⊙ = 2/REV; △ = 4/REV; ▽ = 6/REV; ◇ = 8/REV

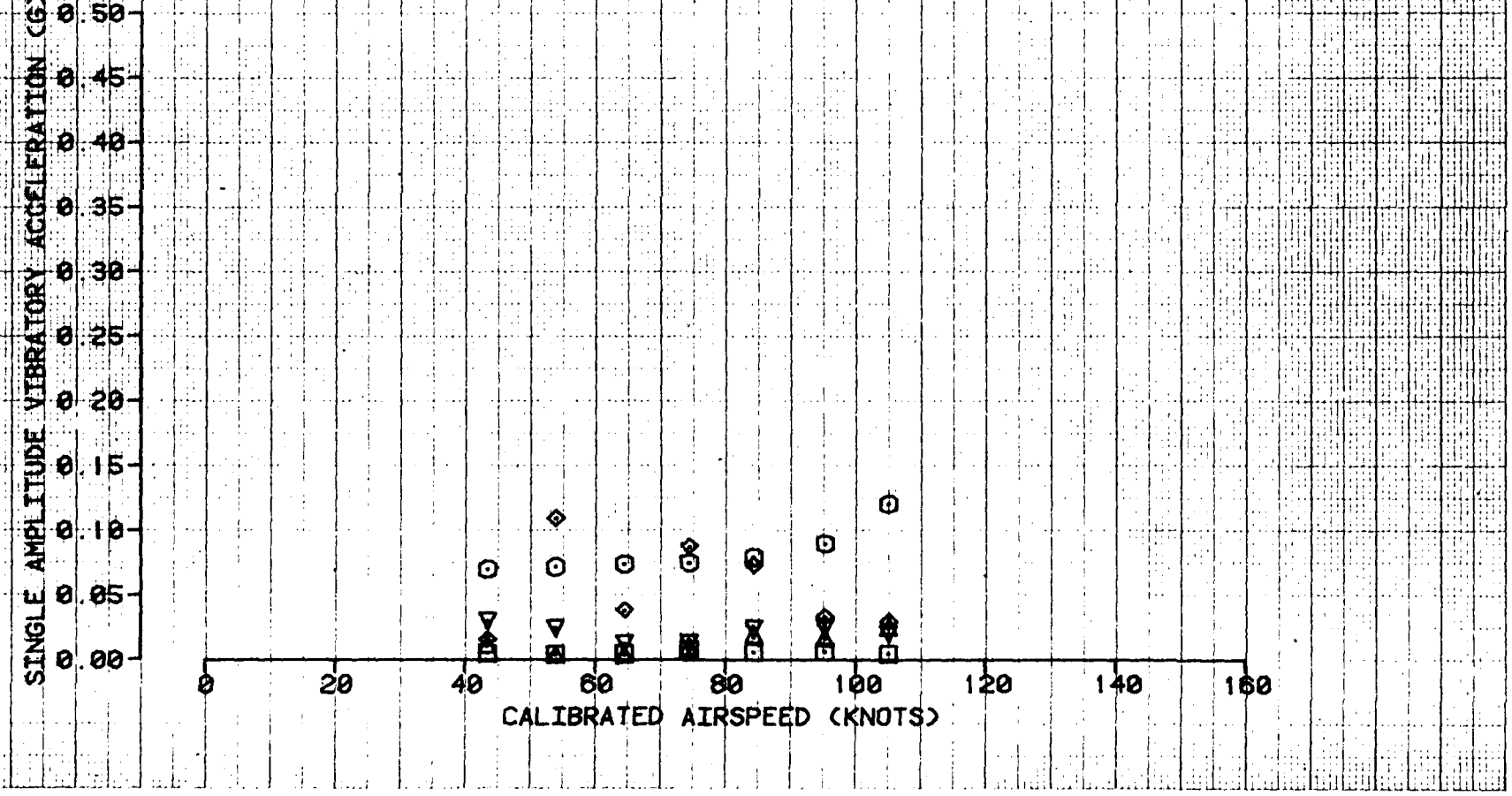


FIGURE E-138

CENTER OF GRAVITY VERTICAL VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
8840	138.1	0.0	6140	1.0	313	LEVEL	CMRB/HUB SPRNG

NOTE: ⊡ = 1/REV; ⊙ = 2/REV; △ = 4/REV; ▽ = 6/REV; ◇ = 8/REV

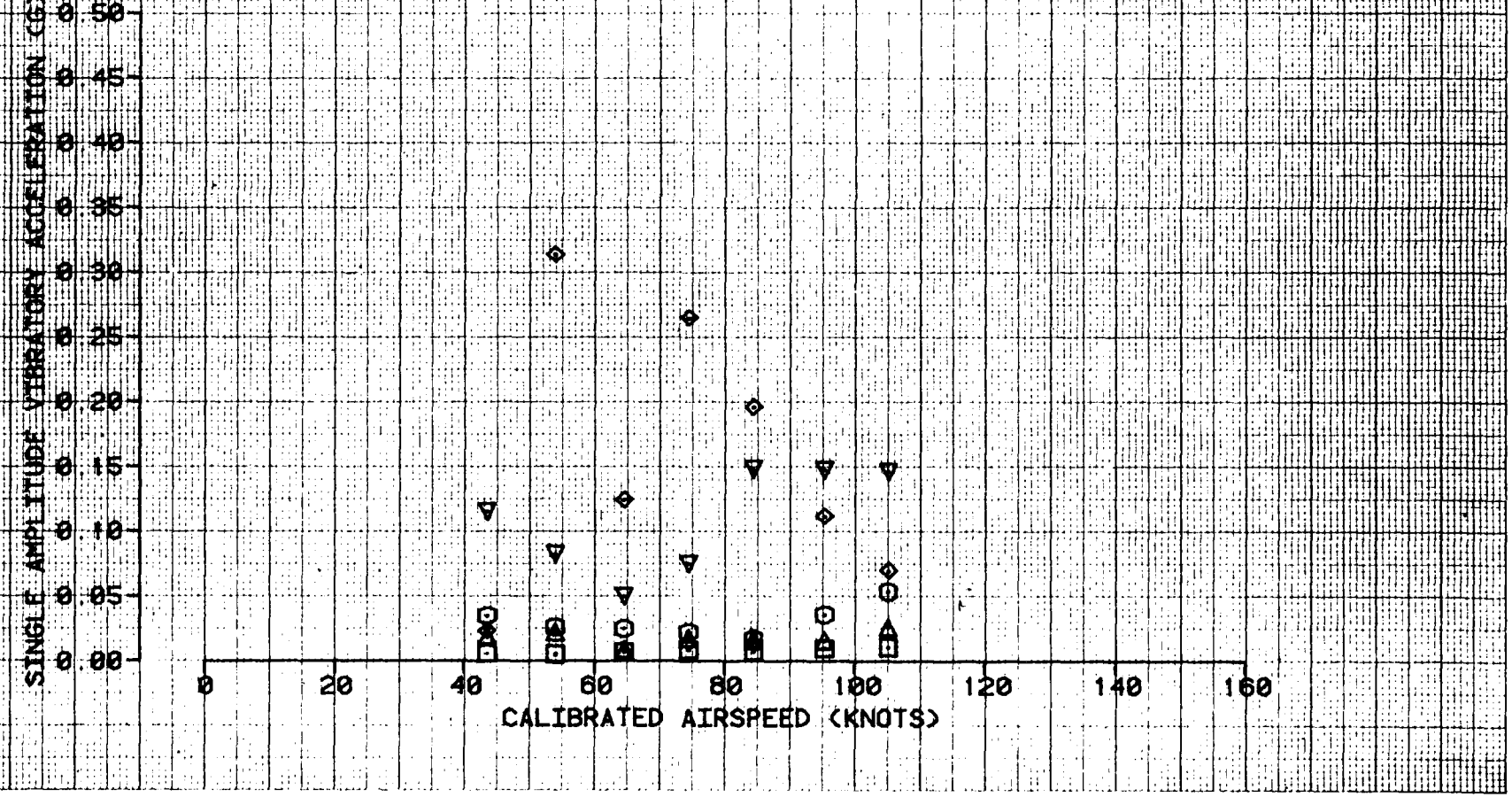


FIGURE E-139

PILOT SEAT VERTICAL VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIB AIRSPEED	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
8690	137.6	0.0	6150	1.0	314	96	WIND UP TURN	CMRB/HUB SPRNG

NOTE: □ = 1/REV, ○ = 2/REV, △ = 4/REV, ▽ = 6/REV, ◇ = 8/REV

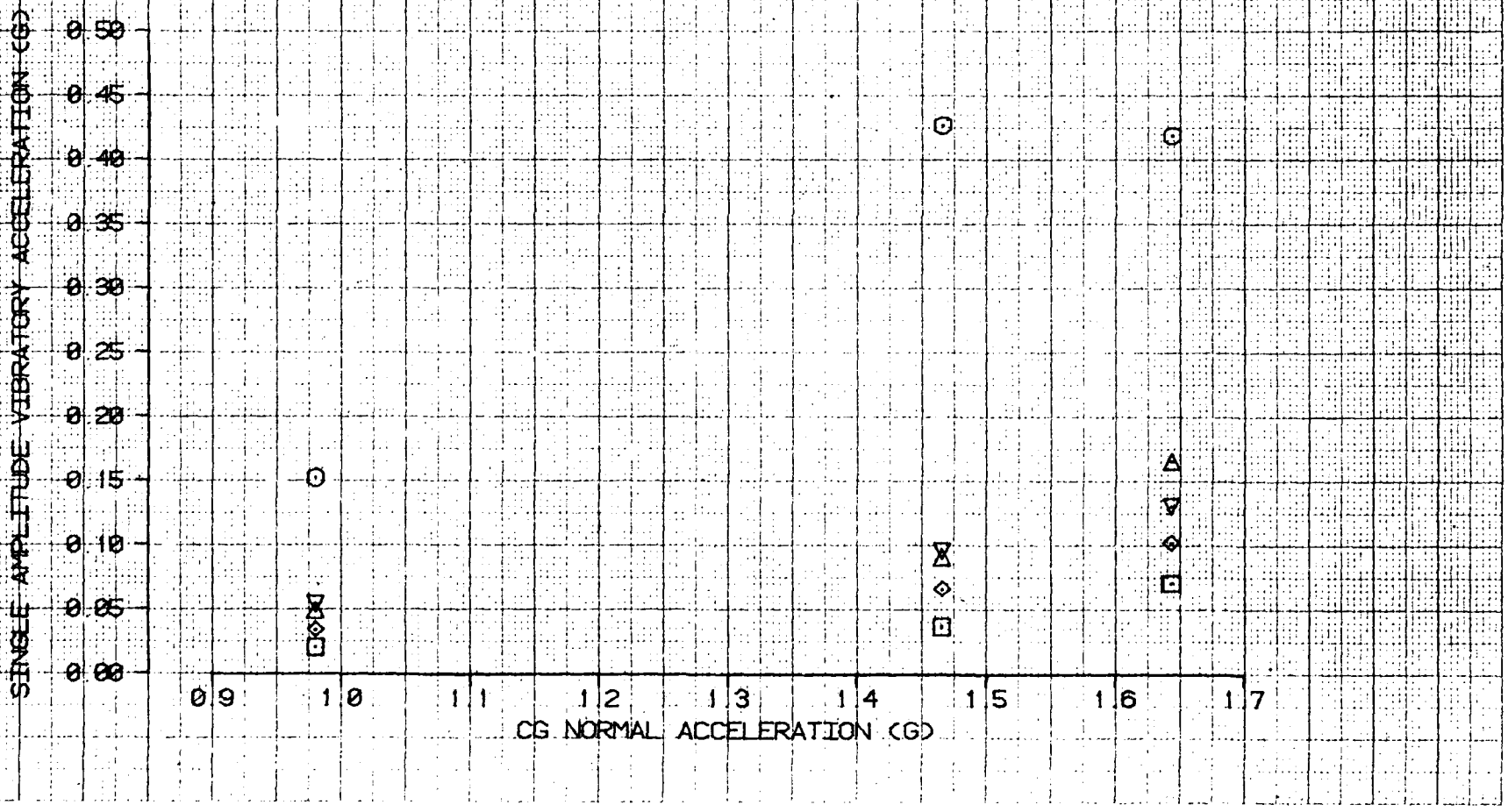


FIGURE E-1[illegible]

PILOT SEAT LATERAL VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIB AIRSPEED	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
8690	137.6	0.0	6150	1.0	314	96	WIND UP TURN	CMRB/HUB SPRNG

NOTE: □ = 1/REV, ○ = 2/REV, △ = 4/REV, ▽ = 6/REV, ◇ = 8/REV

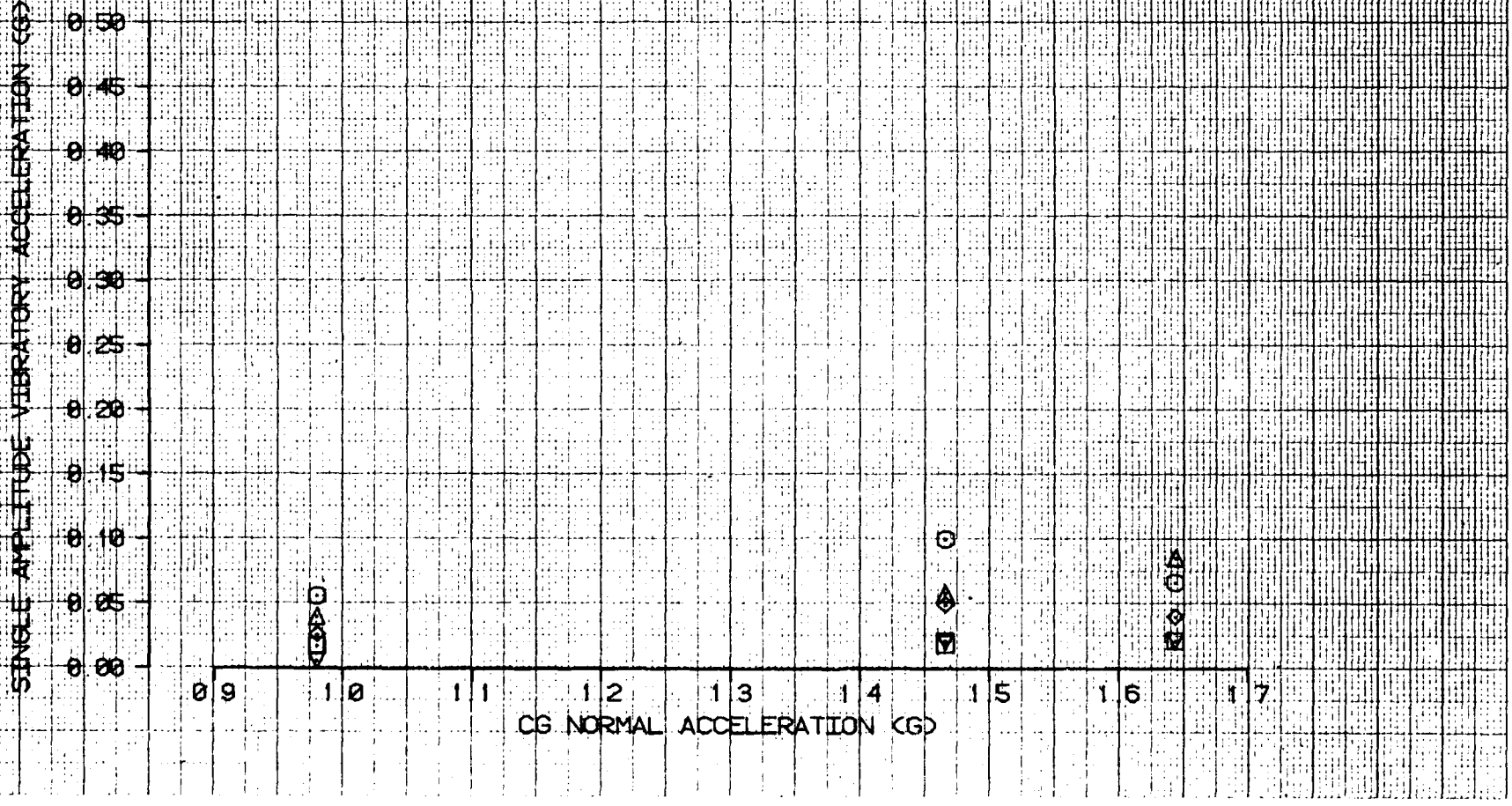


FIGURE 2E-141

PILOT SEAT LONGITUDINAL VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-15358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIB AIRSPEED	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
8690	137.6	0.0	6150	1.0	314	96	WIND UP TURN	CHRG/HUB SPRNG

NOTE □ = 1/REV, ○ = 2/REV, △ = 4/REV, ▽ = 6/REV, ◇ = 8/REV

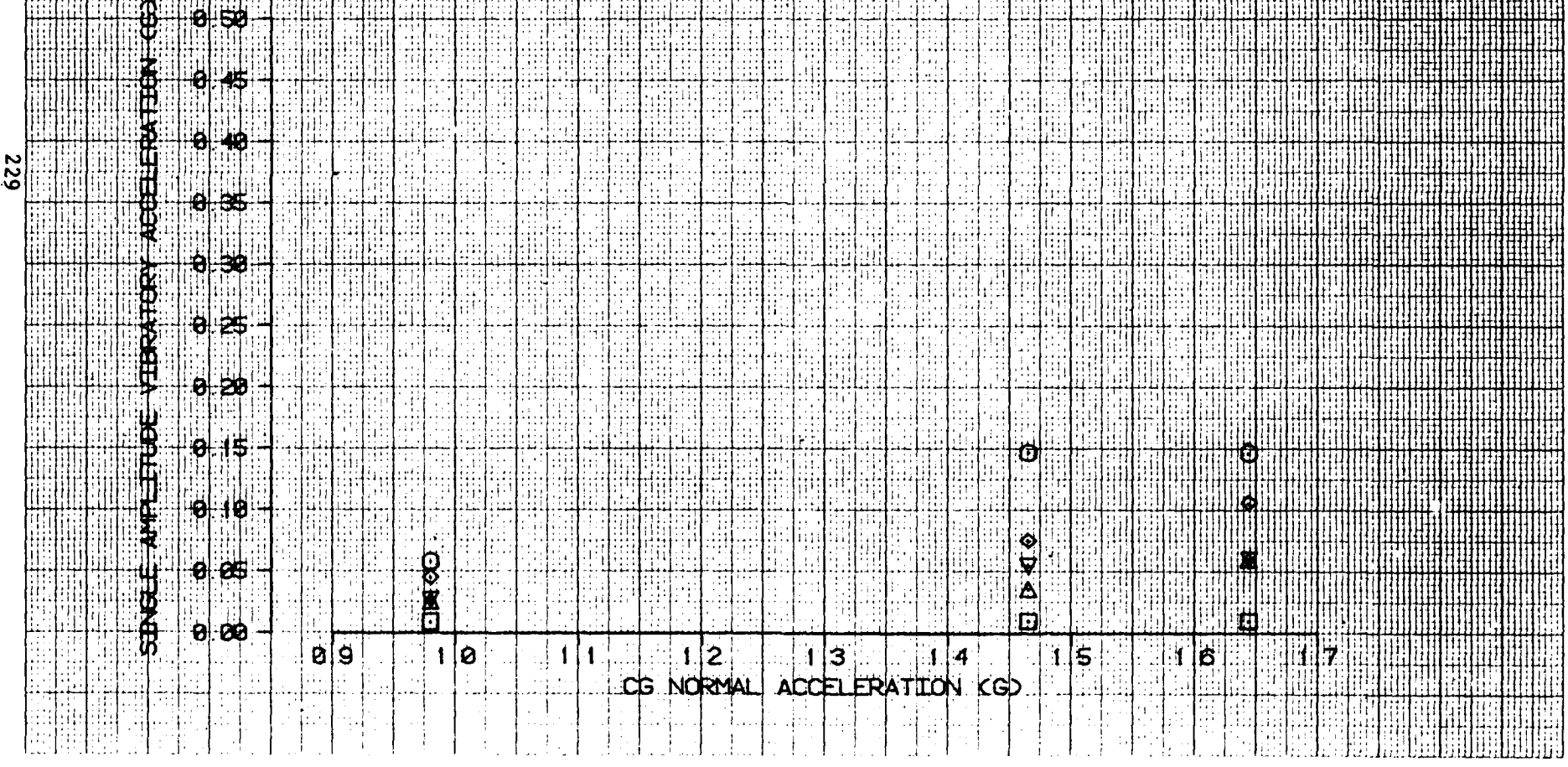


FIGURE 8-142

COPILOT SEAT VERTICAL VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIB AIRSPEED	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
8690	137.6	0.0	6150	1.0	314	96	WIND UP TURN	OMRB/HUB SPRNG

NOTE: □ = 1/REV, ○ = 2/REV, △ = 4/REV, ▽ = 6/REV, ◇ = 8/REV

SINGLE AMPLITUDE VIBRATORY ACCELERATION (G)

0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00

0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7

CG NORMAL ACCELERATION (G)

FIGURE E-143

COPILOT SEAT LATERAL VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIB AIRSPEED	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
8690	137.6	0.0	6150	1.0	314	96	WIND LP TURN	CMRB/HUB SPRNG

NOTE: □ = 1/REV, ○ = 2/REV, △ = 4/REV, ▽ = 6/REV, ◇ = 8/REV

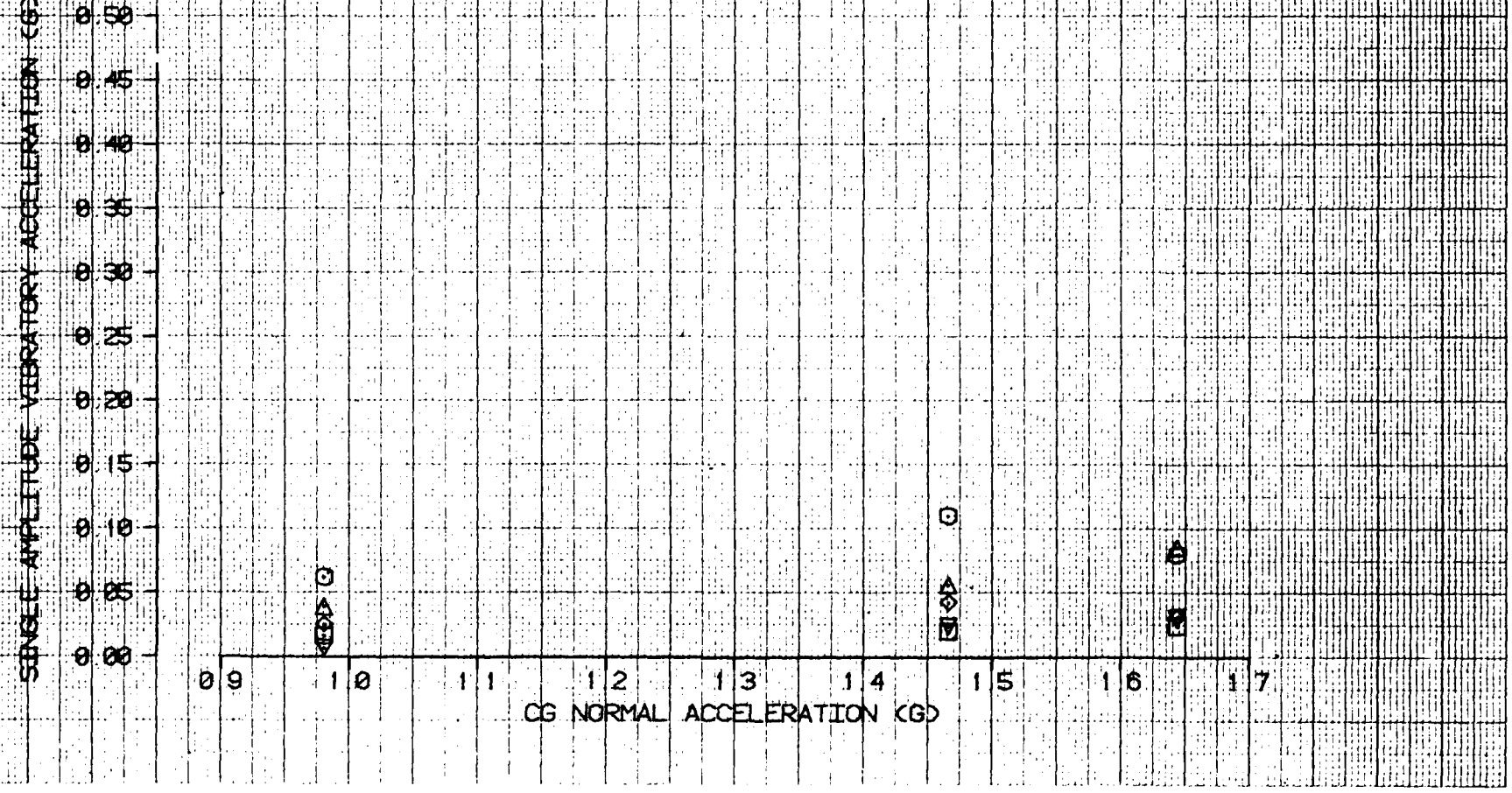


FIGURE E-1444

COPILOT SEAT LONGITUDINAL VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIB AIRSPEED	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
8690	137.6	0.0	6150	1.0	314	96	WIND UP TURN	CMRB/HUB SPRNG

NOTE: ⊡ = 1/REV; ⊙ = 2/REV; △ = 4/REV; ▽ = 6/REV; ◇ = 8/REV

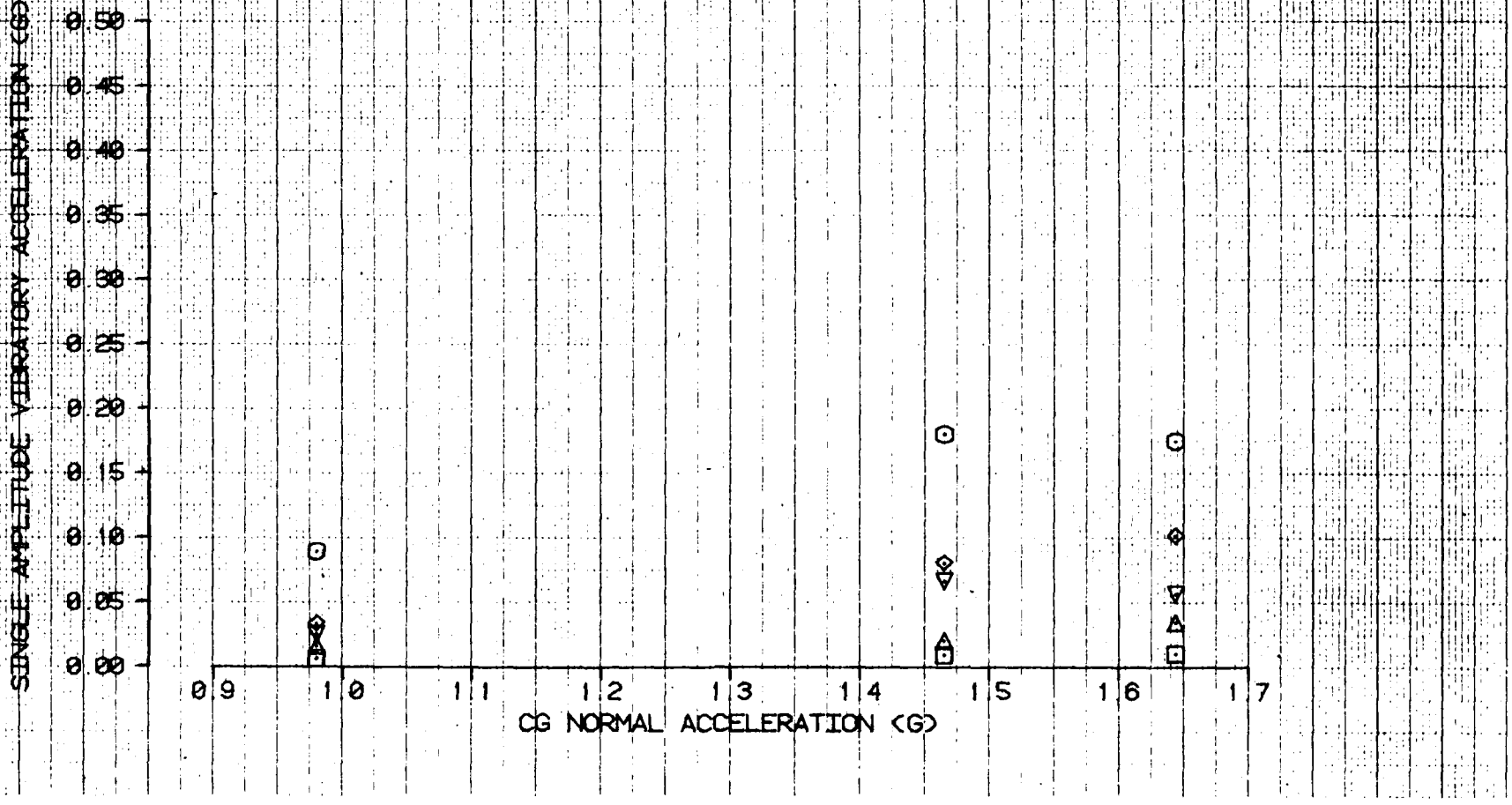


FIGURE E-148

CENTER OF GRAVITY VERTICAL VIBRATION CHARACTERISTICS

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIB AIRSPEED	FLIGHT CONDITION	AIRCRAFT CONFIGURATION
8690	137.6	0.0	6150	1.0	314	96	WIND UP TURN	CMRB/HUB SPRNG

NOTE: □ = 1/REV, ○ = 2/REV, △ = 4/REV, ▽ = 6/REV, ◇ = 8/REV

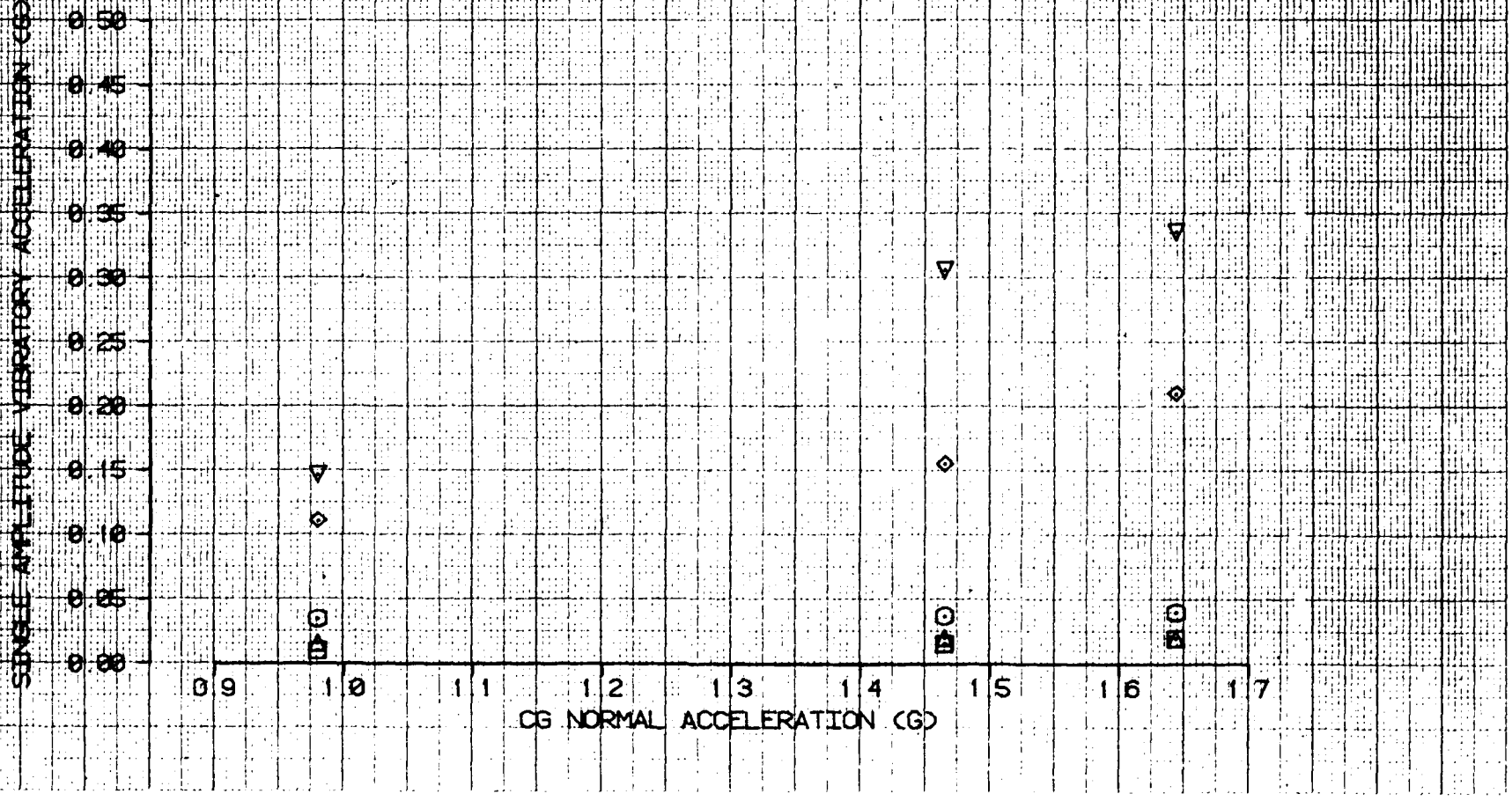


FIGURE E-146b

VIBRATION CHARACTERISTICS IN TRIMMED LEVEL FLIGHT

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG ROTOR SPEED (RPM)
8400	140(AFT)	0.0	8000	314

NOTES: 1. A PROD CMRB/HUB SPRNG CONFIGURATION
2. ⊙ STD/HUB SPRNG CONFIGURATION

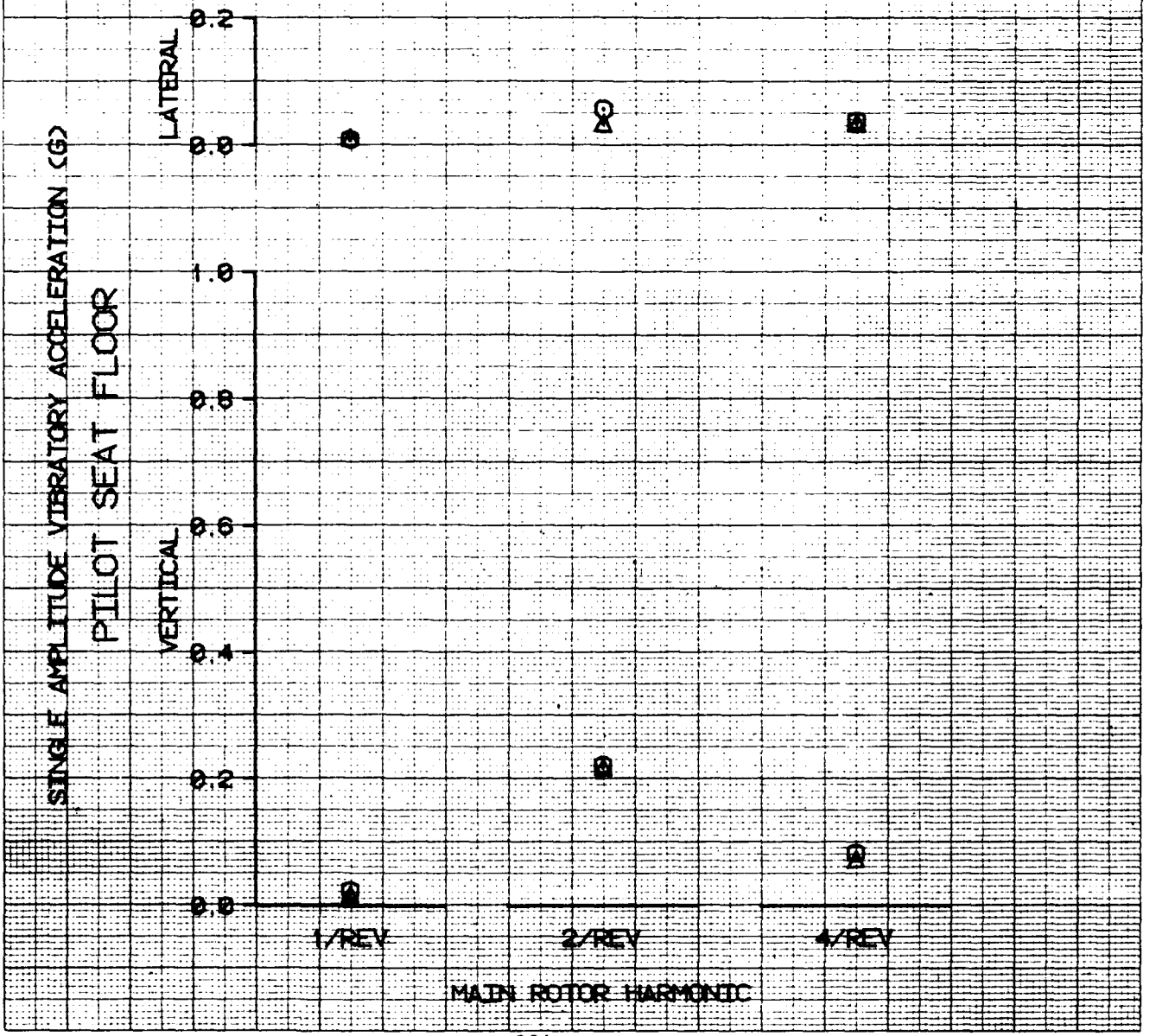


FIGURE 6-149

VIBRATION CHARACTERISTICS IN TRIMMED LEVEL FLIGHT

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG ROTOR SPEED (RPM)
8400	140(AFT)	0.2	8000	314

NOTES: 1. A PROD ORB/HUB SPRNG CONFIGURATION
2. ⊡ STD/HUB SPRNG CONFIGURATION

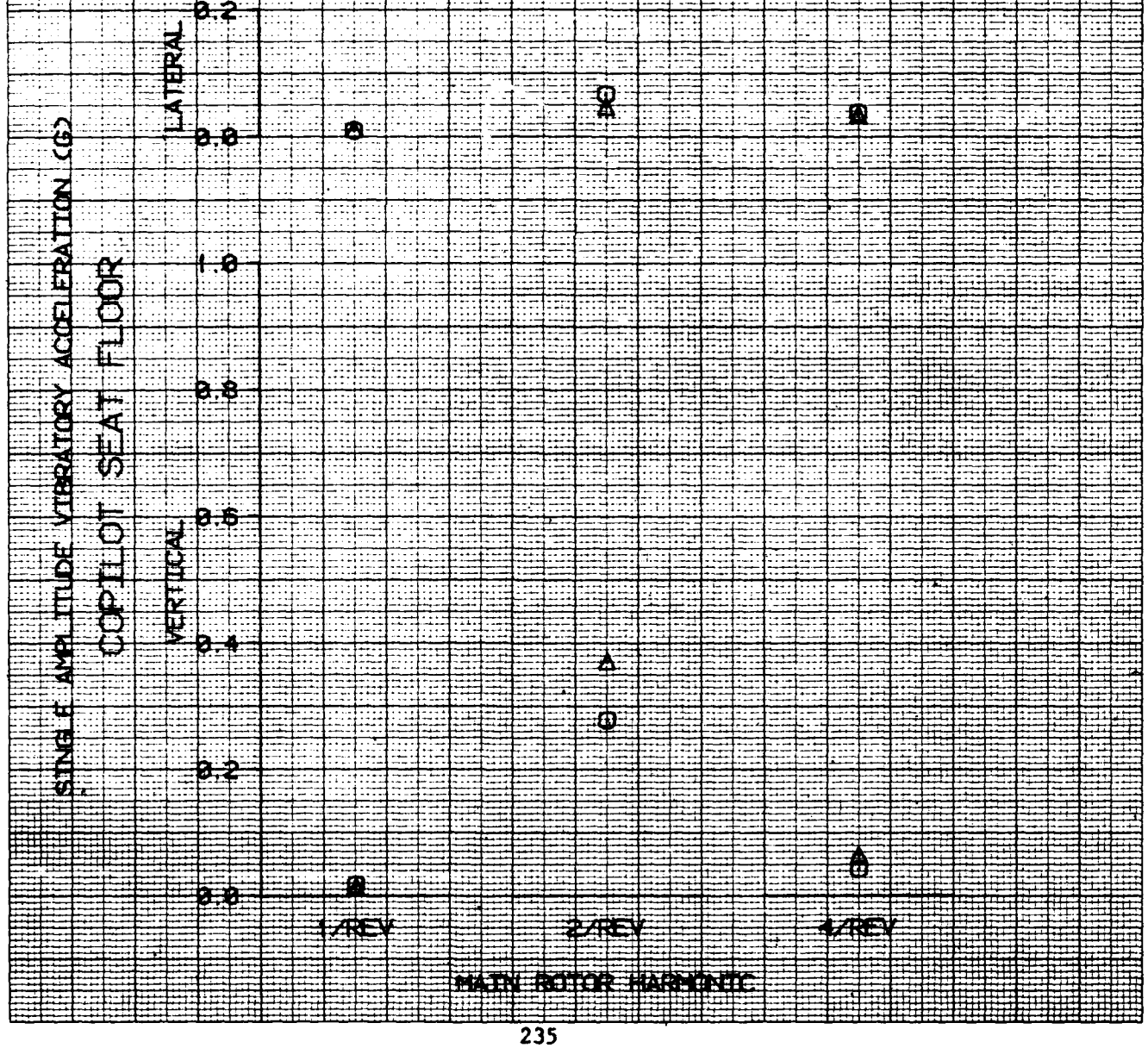


FIGURE 6-148

VIBRATION CHARACTERISTICS PRECEDING FEEDBACK

UH-1H USA S/N 66-16958

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG ROTOR SPEED (RPM)
8400	140 (AFT)	0.0	8000	314

NOTES: 1. △ PROD CMRB/HUB SPRING CONFIGURATION
2. ⊙ STD/HUB SPRING CONFIGURATION

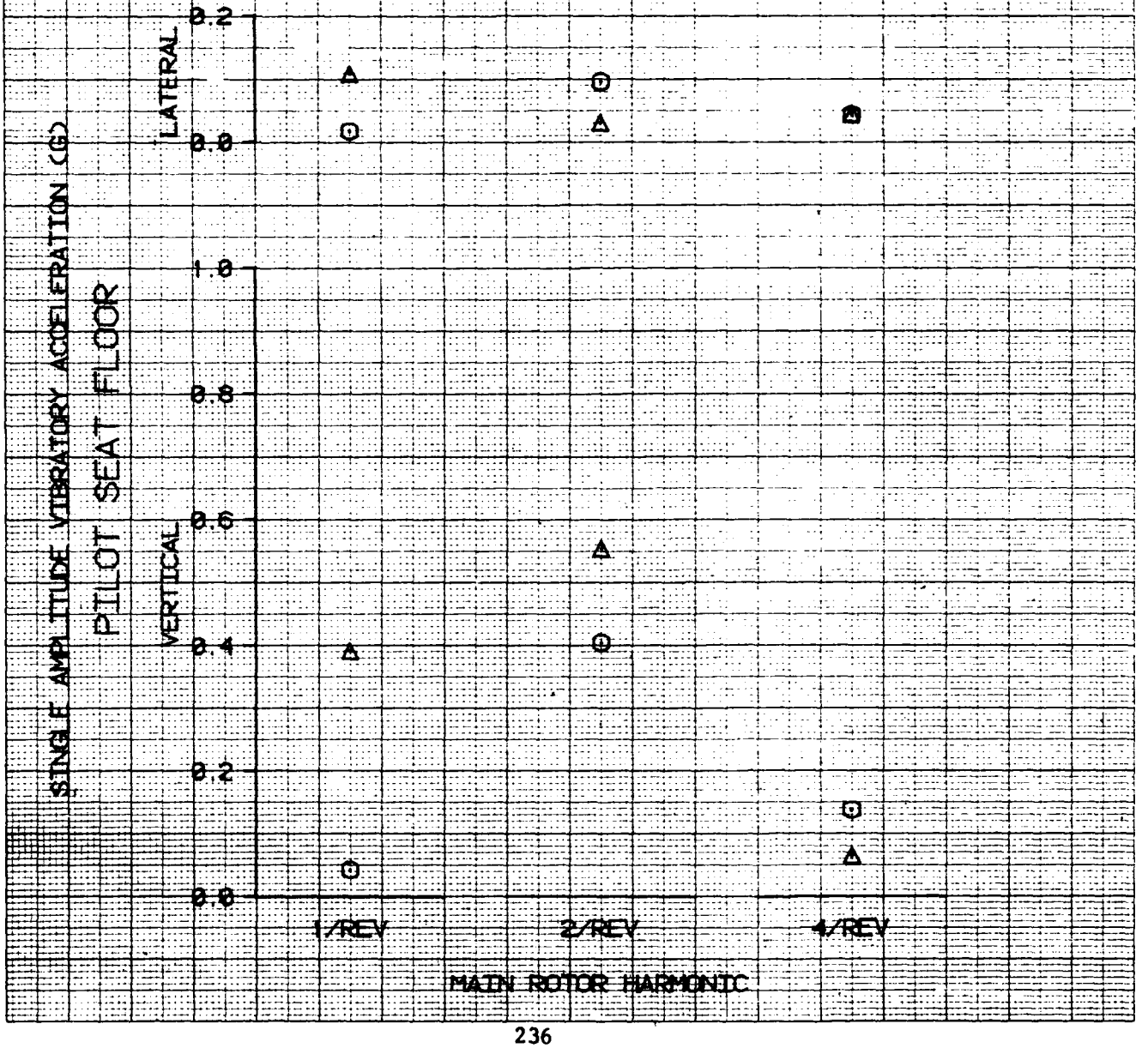


FIGURE 6-140

VIBRATION CHARACTERISTICS PRECEDING FEEDBACK

UH-1H USA S/N 66-16958

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG ROTOR SPEED (RPM)
8400	140(AFT)	0.0	8000	314

NOTES: 1. △ PROD ORB/HUB SPRING CONFIGURATION
2. ⊙ SID/HUB SPRING CONFIGURATION

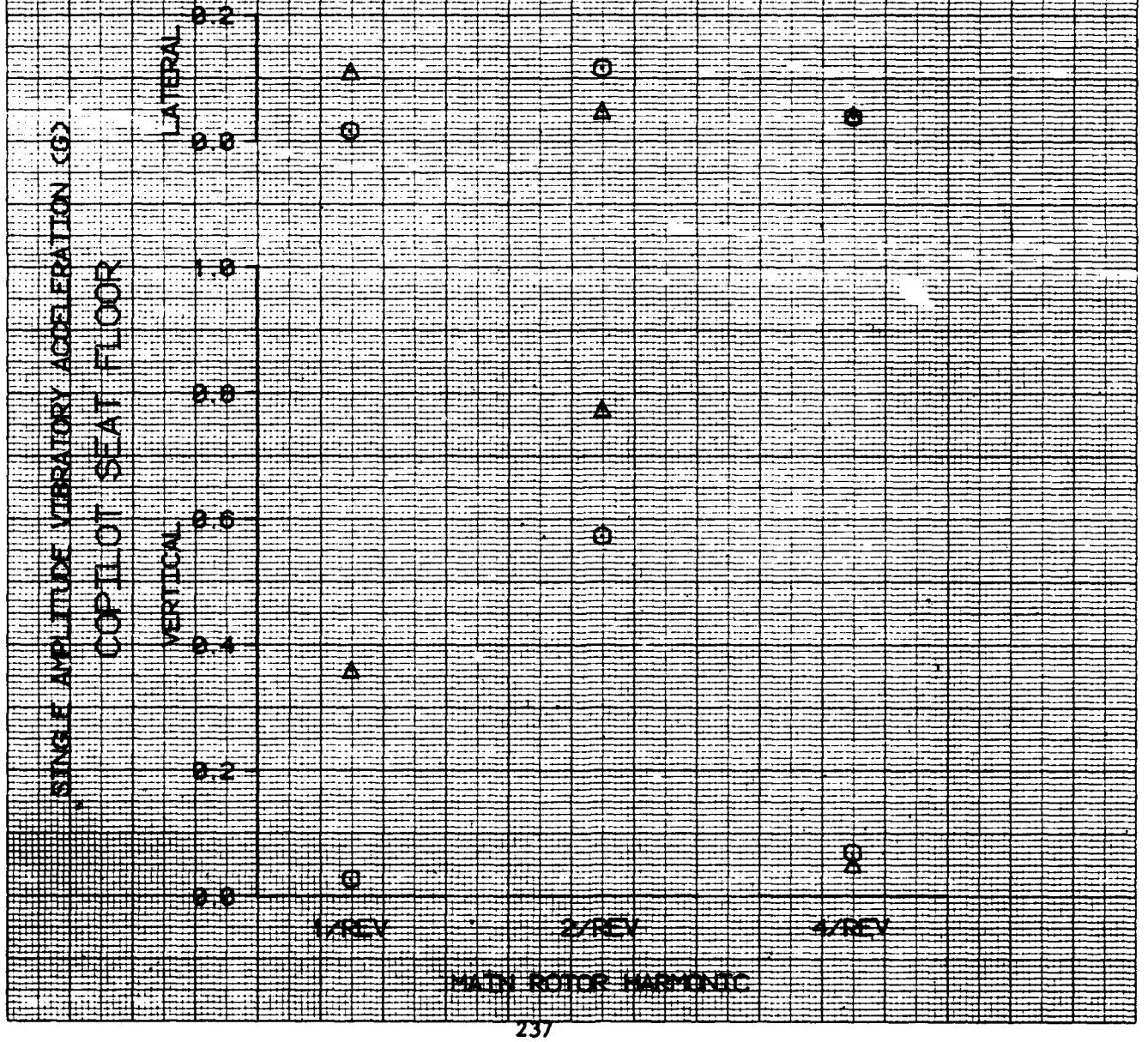


FIGURE 6-150
VIBRATION CHARACTERISTICS DURING FITDBACK
UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG ROTOR SPEED (RPM)
8400	148(AFT)	0.0	8000	314

NOTES: 1. △ PROD CMRB/HUB SPRING CONFIGURATION
2. ○ STD/HUB SPRING CONFIGURATION

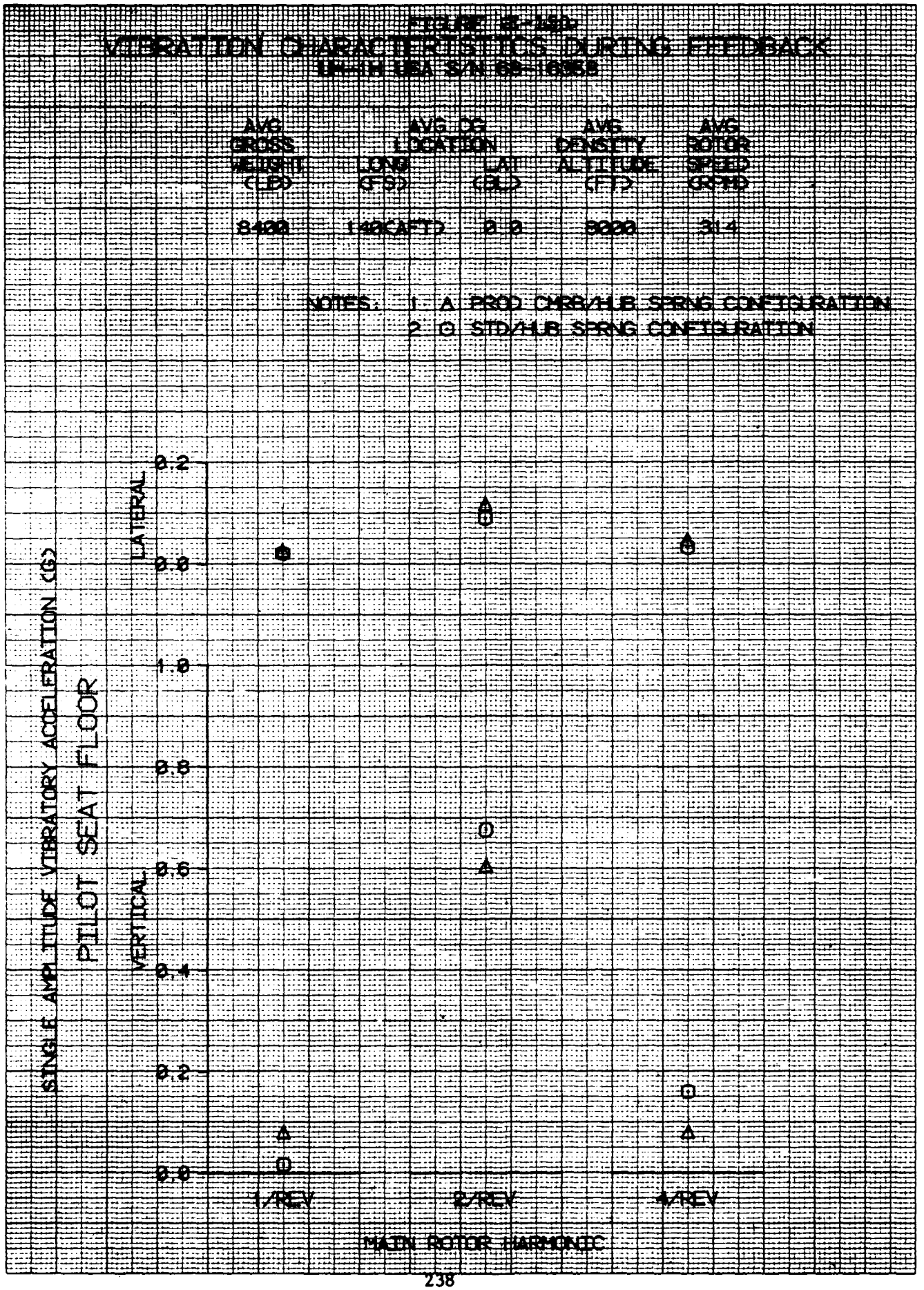


FIGURE 4-151.

VIBRATION CHARACTERISTICS DURING FEEDBACK

UH-1H USA S/N 68-16358

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG ROTOR SPEED (RPM)
8400	140 (AFT)	0.0	8000	314

NOTES: 1. Δ PROD CMRB/HUB SPRNG CONFIGURATION
2. ⊙ STD/HUB SPRNG CONFIGURATION

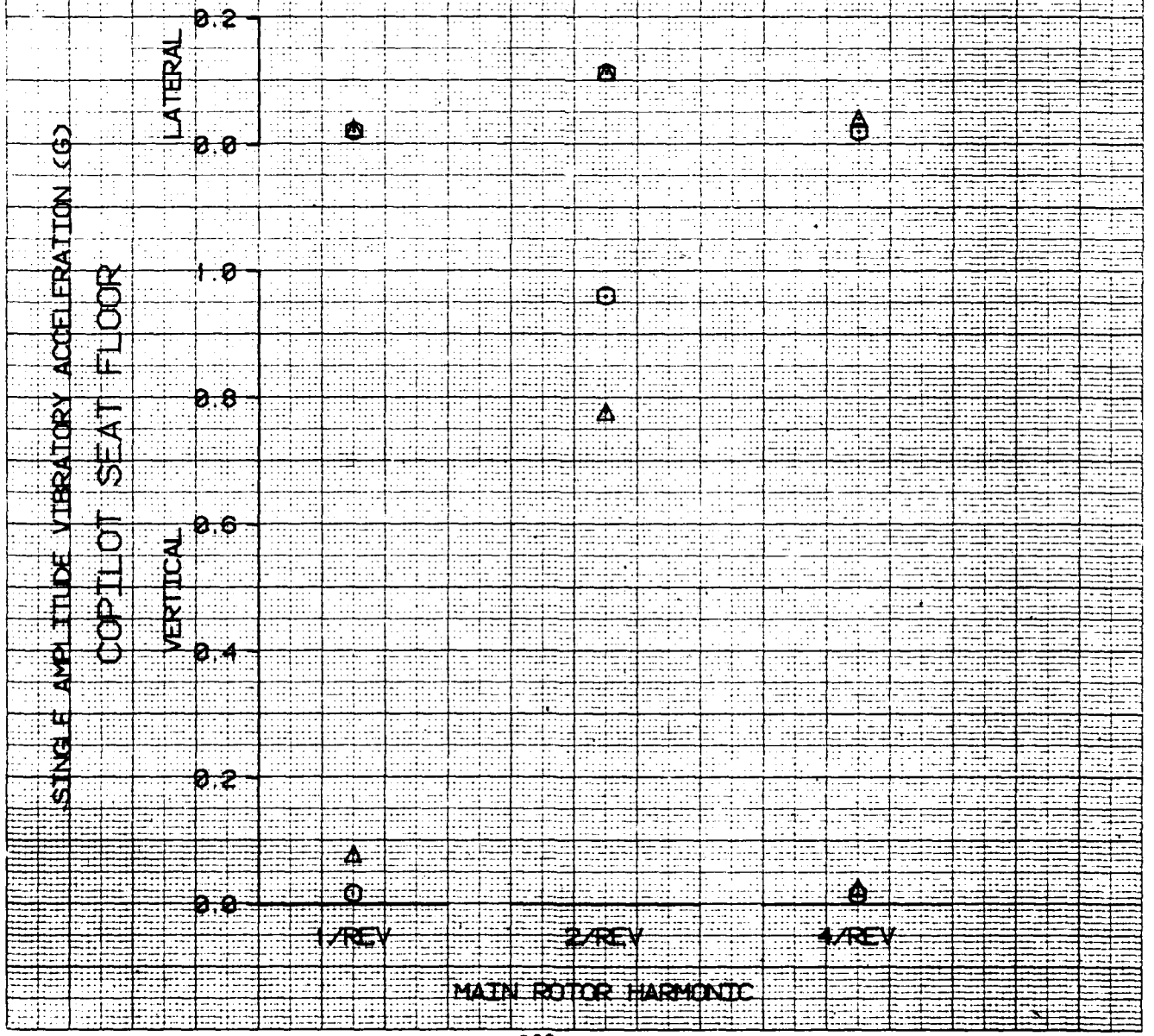


FIGURE E-152

CONTROL LOADS

UH-1H USA S/N 66-16358

GROSS WEIGHT = 8400 LB

NOTES:
1. △ PROD CMRB/HUB SPRNG CONFIGURATION
2. ⊙ STD/HUB SPRNG CONFIGURATION
3. SHADED SYMBOLS DENOTE FEEDBACK
4. CALIBRATED AIRSPEED = 95 KNOTS
5. MAIN ROTOR SPEED = 314 RPM

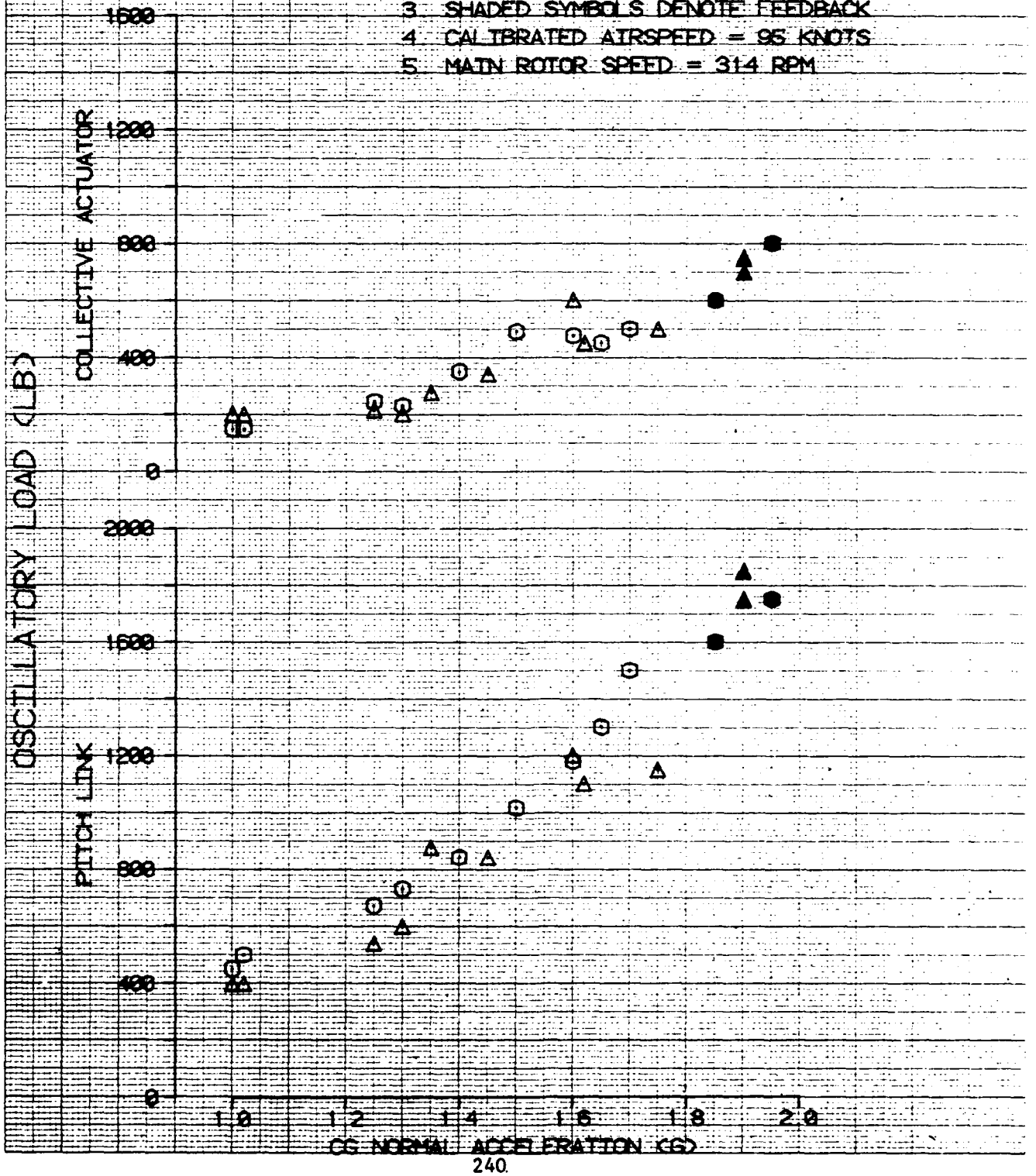


FIGURE E-153

CONTROL LOADS

UH-1H USA S/N 66-16358

GROSS WEIGHT = 8400 LB

NOTES:
1. Δ PROD CMRB/HUB SPRNG CONFIGURATION
2. ⊙ STD/HUB SPRNG CONFIGURATION
3. SHADED SYMBOLS DENOTE FEEDBACK
4. CALIBRATED AIRSPEED = 95 KNOTS
5. MAIN ROTOR SPEED = 314 RPM

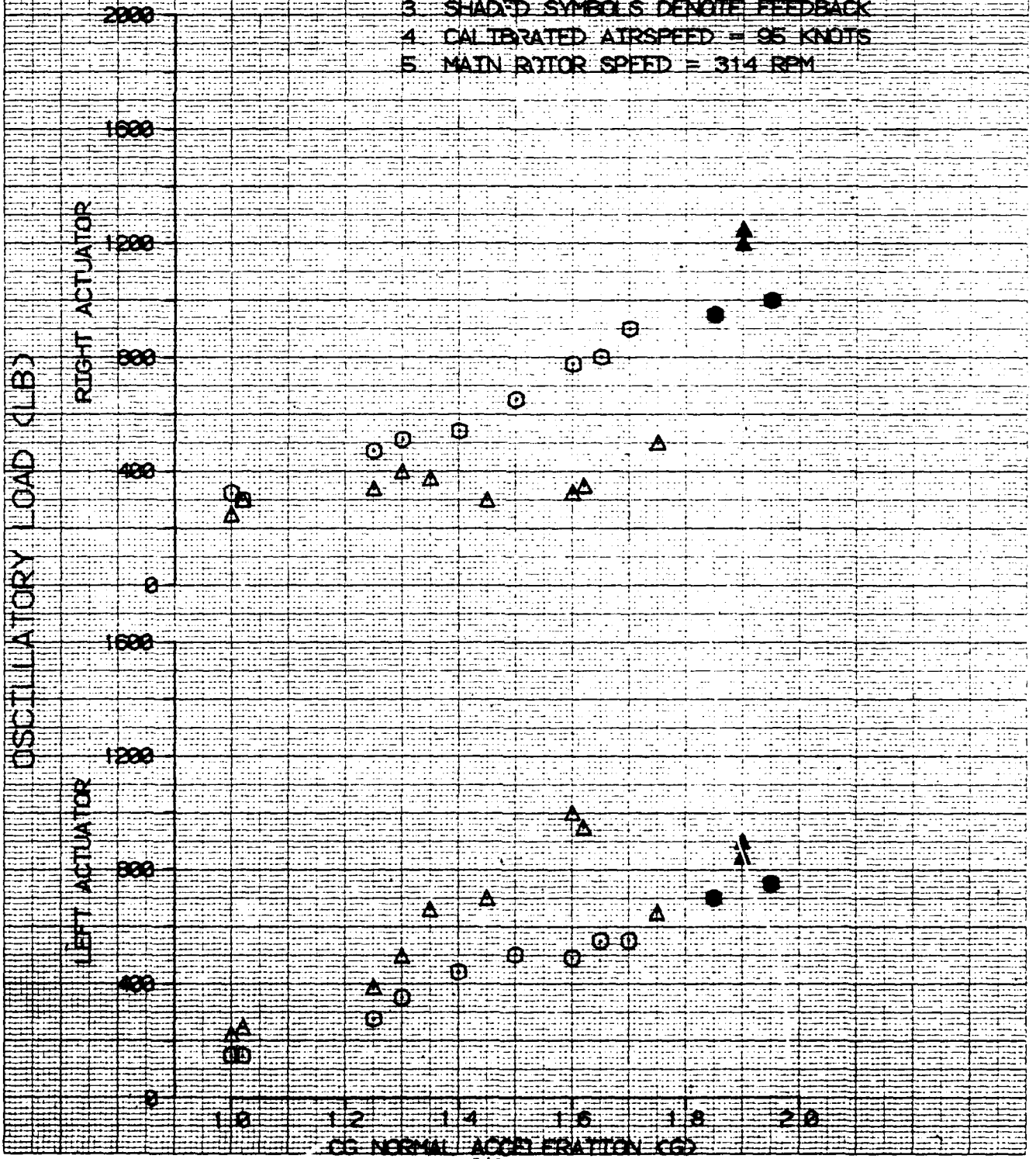


FIGURE B-154

CONTROL LOADS

UH-1H USA S/N 66-16358

GROSS WEIGHT = 8400 LB

NOTES:
1. Δ PROD CMRB/HUB SPRING CONFIGURATION
2. ○ STD/HUB SPRING CONFIGURATION
3. SHADED SYMBOLS DENOTE FEEDBACK
4. CALIBRATED AIRSPEED = 95 KNOTS
5. MAIN ROTOR SPEED = 314 RPM

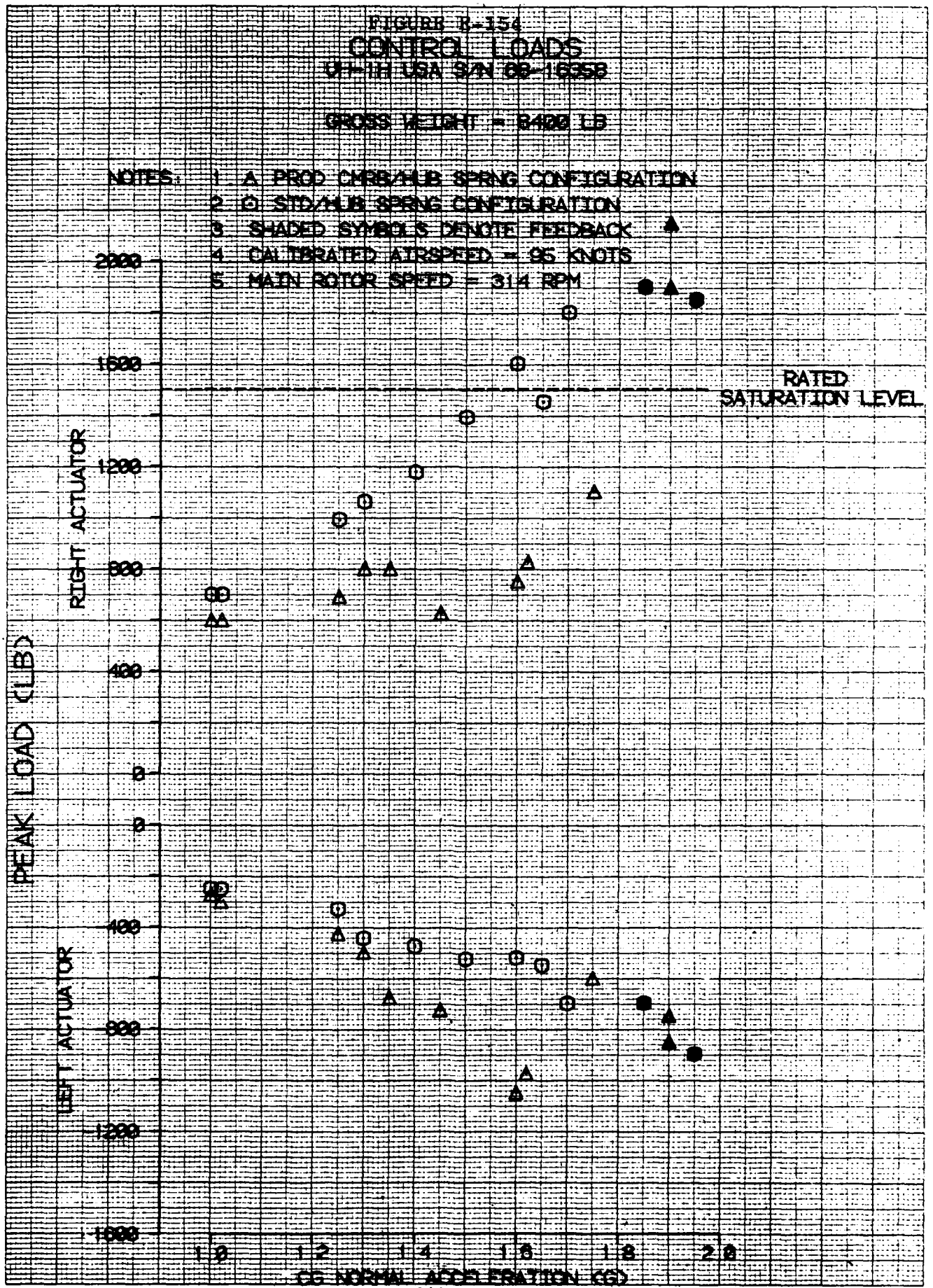


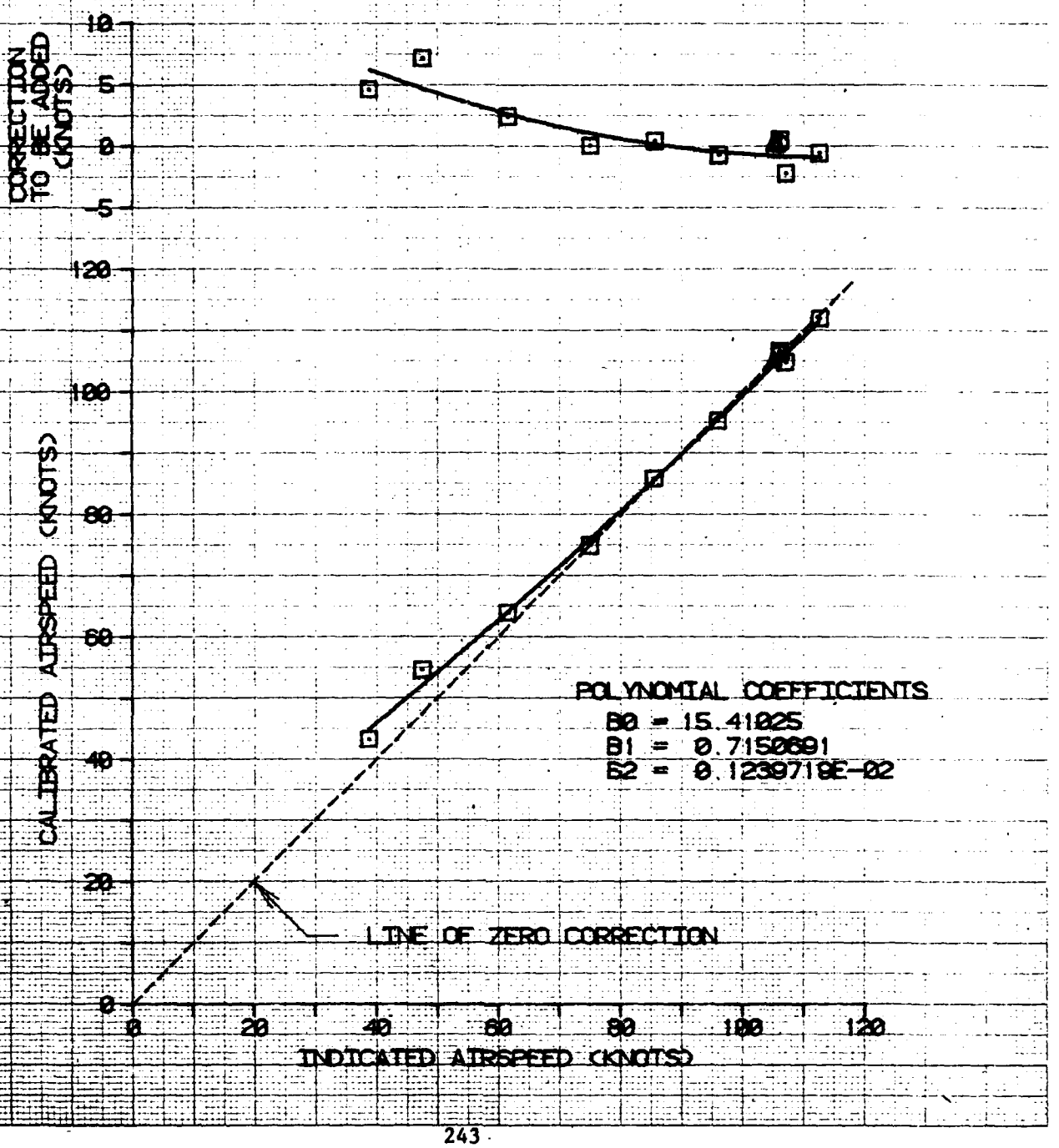
FIGURE 6-152

SHIP SYSTEM AIRSPEED CALIBRATION

UH-1H USA S/N 68-16358

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION
⊡	7900	136.2	0.2LT	3650	22.0	323	LEVEL

NOTES:
1. MEASURED GROUND SPEED COURSE
2. CMRB/HUB SPRNG CONFIGURATION
3. ROOF MOUNTED PROBE
4. WIRE CUTTER INSTALLED
5. ⊖- DENOTES ROTOR SPEED = 303 RPM
6. A- DENOTES ROTOR SPEED = 294 RPM



APPENDIX F. TEST INCIDENT REPORTS

The following Test Incident Reports (TIR's) were submitted during the test program.

TIR No.	Date Submitted	Descriptive Title
EJ-A843301	7 May 87	Excessive play of right cyclic servo universal (swivel).
EJ-A843302	7 May 87	Leaking left cyclic servo.
EJ-A843303	7 May 87	Broken right damper mount bracket.
EJ-A843304	7 May 87	Sheared head of single bolt on damper mount assembly.
EJ-A843305	7 May 87	Loose damper mount assembly bearing.
EJ-A843306	7 May 87	Excessive play in collective servo uniball area.
EJ-A843307	7 May 87	Contact between outer flange fitting and middle shaft flange of K-flex drive shaft.
EJ-A8433-08	15 Jul 87	Excessive damage to white blade scissors.
EJ-A8433-09	15 Jul 87	Grooves worn where bolt and bearing mate to collective sleeve.
EJ-A8433-10	15 Jul 87	Fatigue failure of ball bearing race on white blade scissors assembly.
EJ-A8433-11	15 Jul 87	Excessive wear by loose ball bearings on thin flat washer of white blade scissors assembly.
EJ-A8433-12	15 Jul 87	Impressions from loose ball bearings on face of large flat washer of white blade scissors assembly.
EJ-A8433-13	15 Jul 87	Excessive wear of white blade scissors liner bearing housing assembly.
EJ-A8433-14	15 Jul 87	Damaged shim of white blade scissors assembly.
EJ-A8433-15	15 Jul 87	Signs of high loading on outer casing of ball bearing stack of white blade scissors assembly.

EJ-A8433-16	15 Jul 87	Signs of high loading on shear bolt in both red and white blade scissors assembly.

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US Training and Doctrine Command (ATCD-T, ATCD-B)	2
US Army Aviation Systems Command (AMSAV-8, AMSAV-Q, AMSAV-MC, AMSAV-ME, AMSAV-L, AMSAV-N, AMSAV-GTD)	8
US Army Test and Evaluation Command (AMSTE-TE-V, AMSTE-TE-O)	2
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Assistant Technical Director for Projects, Code: CT-24 (Mr. Joseph Dunn)	2
6520 Test Group (ENML)	1
Commander, Naval Air Systems Command (AIR 5115B, AIR 5301)	3
Defense Intelligence Agency (DIA-DT-2D)	1
School of Aerospace Engineering (Dr. Daniel P. Schrage)	1
Headquarters United States Army Aviation Center and Fort Rucker (ATZQ-ESO-L)	1
U.S. Army Aviation Systems Command (AMSAV-EA, AMSAV-EF, AMSAV-ECH)	3
U.S. Army Aviation Systems Command (AMCPM-UH-1)	2